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IRON AND STEEL ENGINEER

OCTOBER • 1938

VOL. XV NO. X

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Published Monthly by

ASSOCIATION OF IRON AND STEEL ENGINEERS

Entered as second-class matter January 25th, 1924, at Pittsburgh, Pa., under the Act of March 3rd, 1879. Single Copy Foreign Prepaid $2.00 Single Copy $1.50

Subscription price in U. S. & Canada.....$7.50 per year

Subscription price in foreign countries.....$10.00 per year

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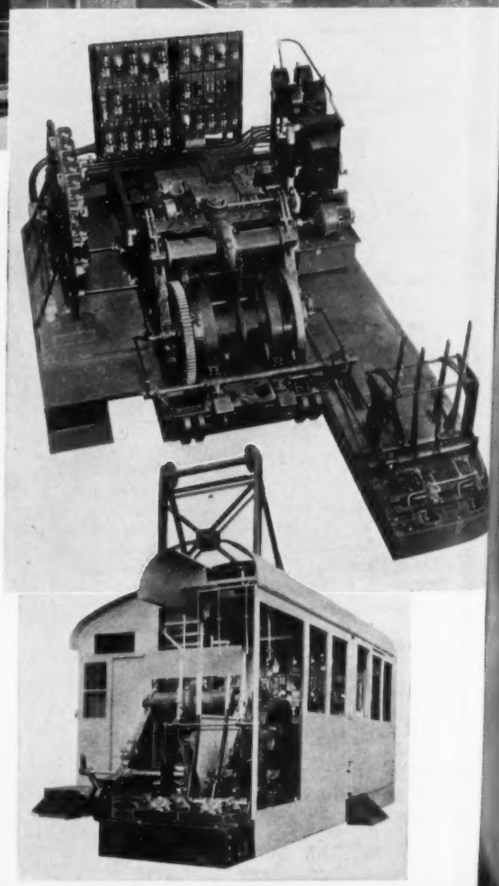

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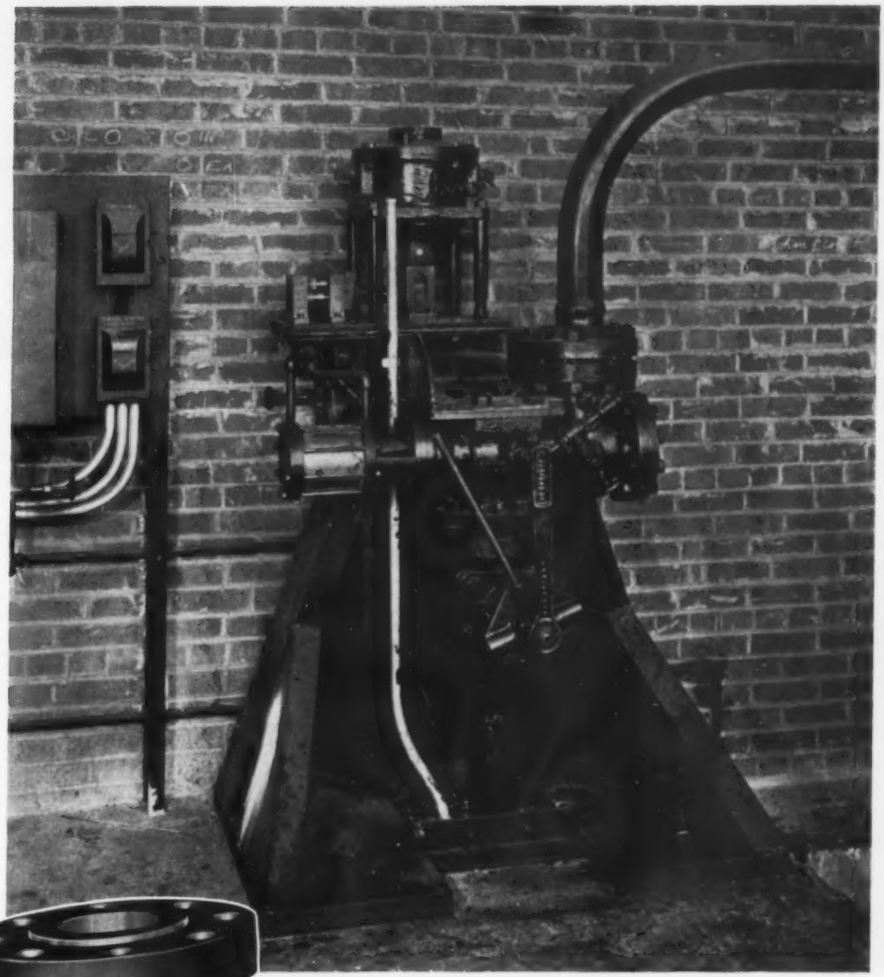

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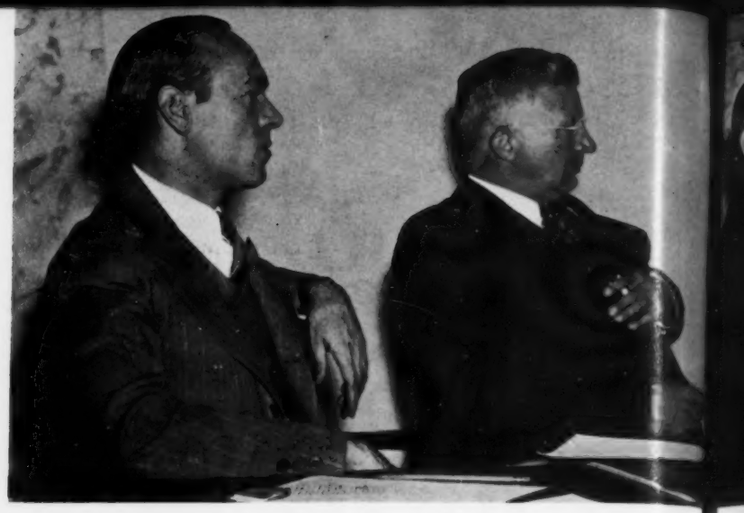


Pictorial

34th ANNUAL

and IRON & STEEL

Marking the highlights of the most successful Convention and Exposition ever held by the Association of Iron & Steel Engineers, this pictorial story well serves to review the week's activities. (Upper right) J. H. Albrecht greets early registrants P. C. Clark and H. J. Fisher. Also early arrivals among the 2500 members and guests who registered at the Convention were Linn O. Morrow, Louis Moses, G. F. Bowers, and L. V. Black (left).

Activities each day began with a conference breakfast (lower left) for the chairman and authors of the day, so

Review of

CONVENTION

EXPOSITION

that the plans and program for the technical sessions might be discussed.

The electrical session on Tuesday was presided over by J. W. Bates and F. O. Schnure (left center above). Speakers at this session included D. C. Nelson and J. R. Powell (left center bottom) and W. B. Snyder (right center bottom). E. C. Marshall (top right) and I. N. Tull (right) were among those who contributed to the discussion at this meeting, which was attended by some 250 individuals.

C. L. McGranahan and J. S. Kenney (right center top) presided at the metallurgical session, which opened with a paper by L. R. Milburn (lower right).

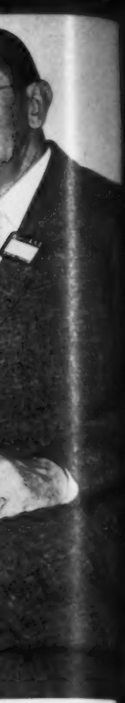
H. W. Neblett (upper left) and H. P. Munger (left) also presented papers at the metallurgical session, which drew approximately 250 interested listeners, among them President L. F. Coffin and President-elect C. C. Wales (below).

The welding session proved quite popular, with an attendance of about 200. G. A. Hughes and Wray Dudley (above) were chairman and vice-chairman, respectively, of this meeting, which included a paper by Dr. Gilbert Doan (lower left).

Technical sessions, probably the most authoritative ever presented before the Association, were well attended. Elmer Weiss, T. E. Hughes and Wray Dudley discuss the meeting as the elevators carry the crowd down from the meeting rooms (opposite page, top).

Members of the Board of Directors toured the Exposition on Tuesday evening, where L. A. Umansky explained some of the high points to Mr. and Mrs. J. A. Clauss, Mr. and Mrs. H. G. R. Bennett, Mr. and Mrs. L. F. Coffin, and A. W. Steed (right).

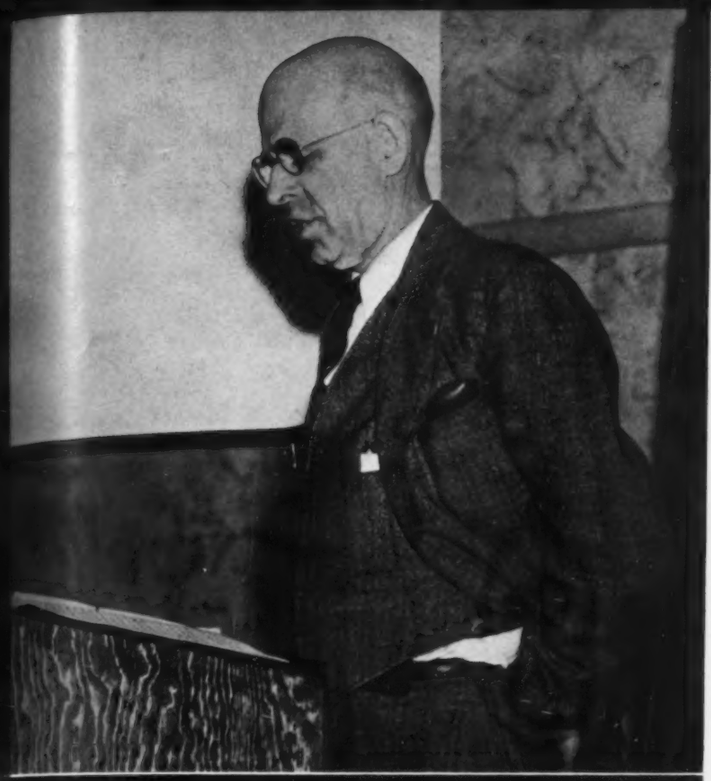
The record attendance of 14,000 attests to the success of the Exposition, which included the exhibits of 105 manufacturers, among which one of the most popular was the operative scale model of the new seamless tube mill of the Youngstown Sheet & Tube Company (opposite page, bottom).



KNOX
ROACH

The Wednesday breakfast meeting (upper left) brought together those participating in the mechanical technical session, which drew an attendance of about 500, J. A. Clauss, chairman, and R. R. Thomas, vice-chairman (left), presided over a program of three papers presented by Lorenz Iversen (lower left), J. L. Young (above), and Stephen Badlam (upper right). R. J. Wean (below) contributed to the discussion at this session.

The inspection trip to the 98″ strip mill of Republic Steel Corporation was attended by 1260 members and guests (opposite page upper right and lower left). This is the largest group that has visited this mill, and demonstrates the interest which this largest and fastest mill in the world has aroused. (Extreme right) F. N. Coakley escorts J. L. Young through the mill, while Harry Holloway and J. N. Hughes assist in welcoming the visitors, including J. A. Clauss, L. R. Milburn, Lorenz Iversen, and John Rock (opposite page, lower right).



Thursday brought four technical sessions. The combustion meeting, at which M. J. Conway and G. E. Coughlin (upper left) presided, presented papers by H. V. Flagg, A. J. Fisher and E. T. W. Bailey (opposite page, top). The attendance of 200 included representatives from the combustion and fuel departments of practically all large steel plants.

W. A. Perry and J. J. Booth (left) were respectively chairman and vice-chairman of Thursdays electrical session, at which papers by T. R. Rhea and M. J. Leding (lower left) and J. H. Cox (above) were presented.

The lubrication meeting was well attended, with papers by Clark Johnson, L. Ballard and R. M. Gordon (opposite page, bottom), with Frank Thomas and C. R. Hand (below) presiding.

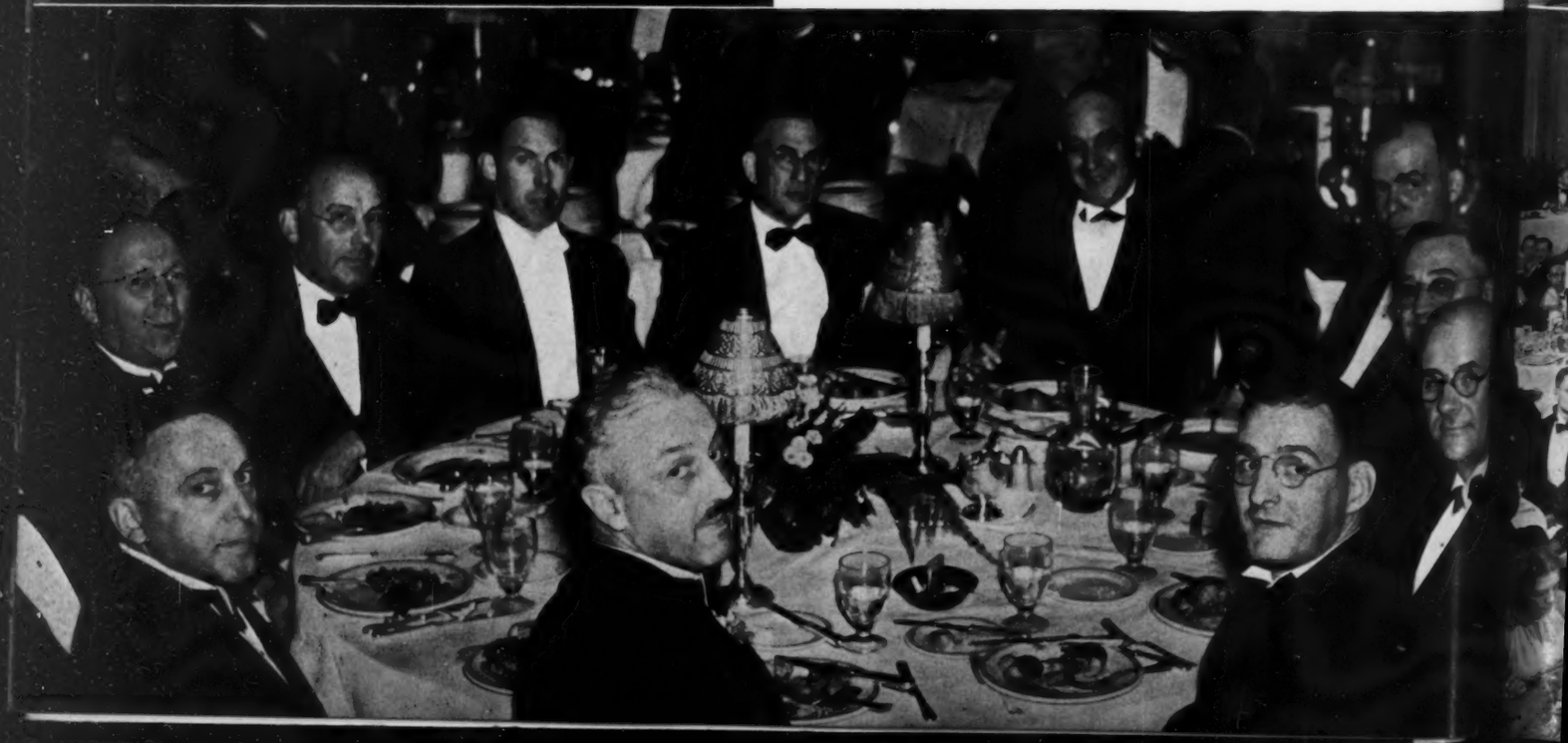
A blast furnace discussion was presented by A. G. McKee (extreme lower right).

An innovation of this Convention was the Old Timers club, consisting of members of twenty or more years standing. This organization was started by T. J. Fleisher, and held a luncheon Thursday noon (right).

J. C. Barrett (left) presented an interesting blast furnace paper at the Thursday session presided over by H. G. R. Bennett and T. B. McElray.

Above is T. B. McElray, L. F. Coffin and L. V. Black, who were among the 350 interested spectators on the inspection trip to the Cleveland plant of Fisher Body Division of General Motors Corporation, held Friday morning.

"All work and no play" was avoided through the medium of the banquet and dance held Thursday night, which was attended by many prominent men of the steel industry. Below is a group of Republic Steel Corporation (operating) executives (from the Cleveland District. On the opposite page, top, are T. M. Girdler, who addressed the gathering, and L. F. Coffin. To the right are James Farrington, C. F. Hood, and C. C. Wales. The banquet was attended by approximately 475 members and guests (lower right).



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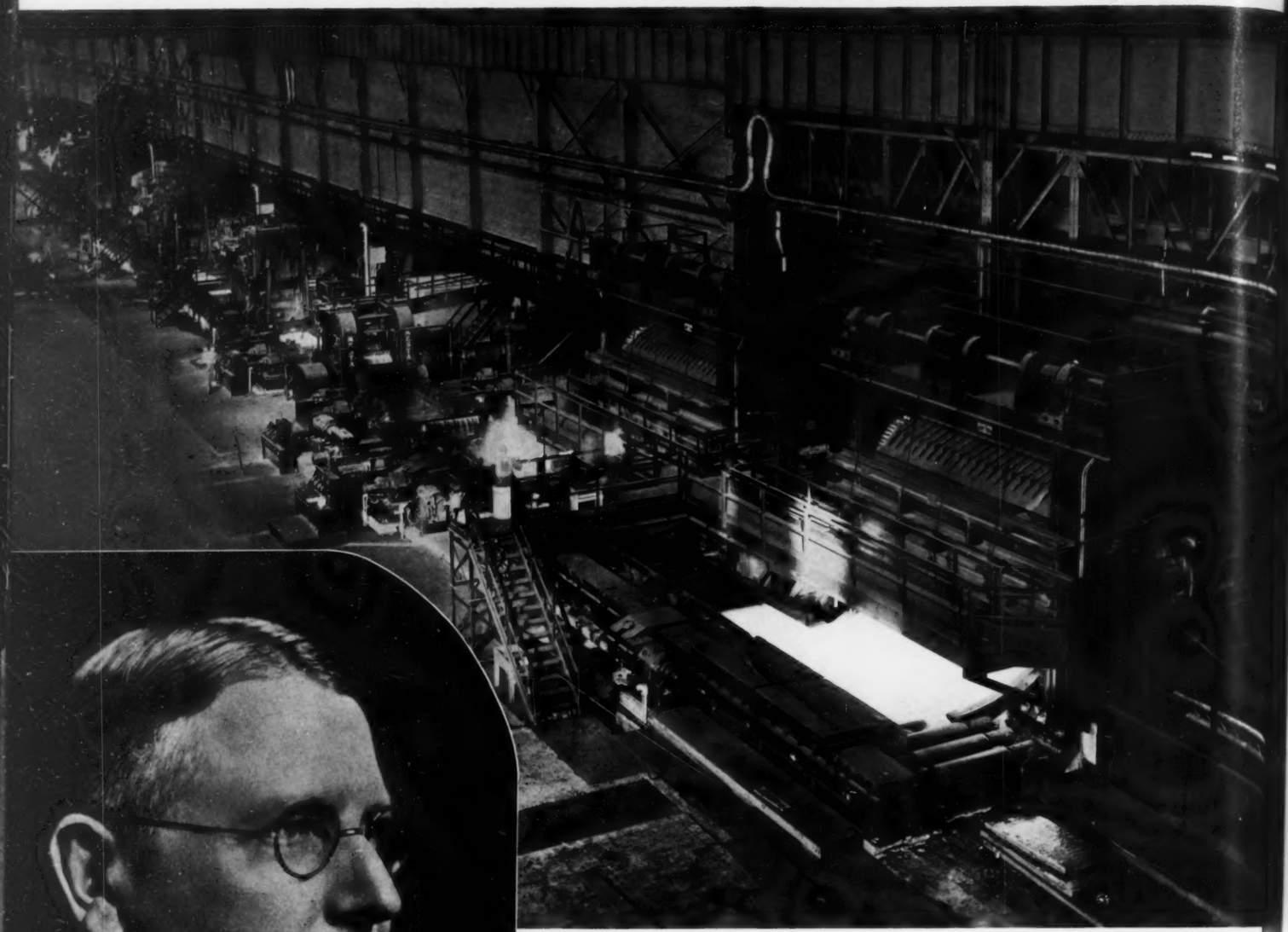


WILFRED SYKES
ASSISTANT TO PRESIDENT
INLAND STEEL COMPANY

▲ THE new 44″ continuous hot strip mill at the Indiana Harbor plant of the Inland Steel Company represents yet another milestone along a road that has been well marked by the constant development and progress of that company. Scarcely a year passes but that Inland announces the completion of a new project of expansion or modernization, and it is this aggressive policy of improvement that has evolved the present well-rounded and highly efficient corporation from the original rolling mill plant built at Chicago Heights in 1893.

Quick to realize the possibilities of the continuous wide strip mill, Inland, in 1932, installed their 76″ strip mill plant, a complete description of which was published in the IRON AND STEEL ENGINEER for September, 1937. With the growing demand for flat rolled products in the steel market, Inland, ever alert to develop facilities to meet such demands, has proceeded with the installation of a new 44″ continuous hot strip mill. This mill will augment and complement the products rolled on the 76″ mill, producing auto-

NEW 44" MILL EXPANDS *Inland's* HOT STRIP CAPACITY

mobile frame stock, barrel stock, coils for subsequent rolling in sheet and tin mills, etc.

The 44" mill is built on made land extending out into Lake Michigan. The fill was made by pumping in sand dredged from the adjacent lake bed, in conjunction with cinder and granulated slag. To stabilize the concrete foundations for the mill, which extend down to slightly below normal lake level, a great quantity of wooden piling, varying 55 to 75 feet in length, was driven down into the original lake bed.

The mill is housed in a group of buildings, dimensions and crane data of which are as follows:

Buildings	Length (Ft.)	Width	Cranes		
			Number	Capacity (Tons)	Span (Ft.)
Slab Yard	1944	84'–4½"	3	25/10	80
Furnace Building	168	54'–4½"	1	3	50
Hot Mill Building	672	84'–4½"	2	60/25	80
Motor Room	530	54'–4½"	1	50/10	50
Finishing and Shipping	672	104'–4½"	2	15	100
Coil and Plate Storage	672	104'–4½"	2	15	100

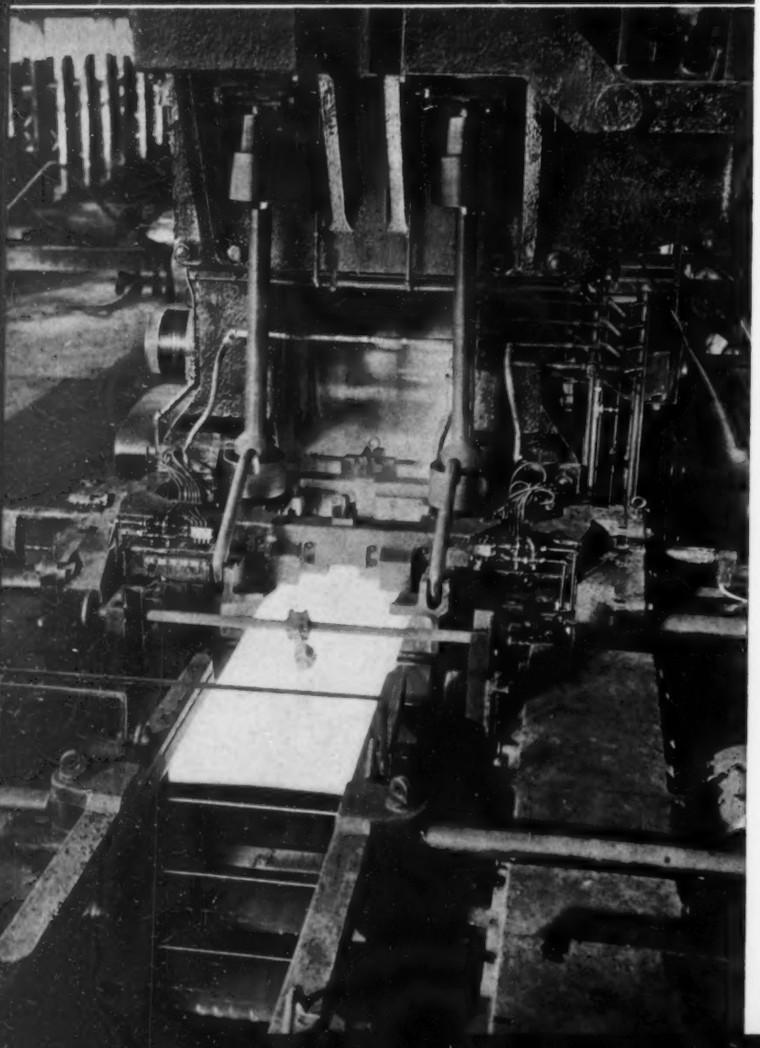
It will be noted that, in the above tabulation, the length of the slab yard is given as 1944 feet. This represents the total length of the yard which serves the previously installed 76" strip mill and 46" blooming mill, as well as the new 44" strip mill, and which continues in line past all three of these mills. This is made possible by the fact that all three mills are in approximate alignment, end to end. In addition to the three cranes given in the foregoing table, there are also three cranes in the slab yard serving the older mills. Space has been left between the blooming mill and the 44" strip mill for future soaking pit extension, if required.

Thus, it may be seen, slabs are delivered directly to the slab yard by a transfer from the blooming mill table, and may be handled by crane alone to either of the strip mills. This plan facilitates delivery, reduces handling, and greatly increases operating efficiency.

The new mill is designed to roll material from No. 20 gauge, 36" wide, up to ⅜" thick, 40" wide, and has a

Skid plates of special design reduce shock as the hot slabs are discharged on to the roller table.

From the furnace, the slab passes through a scalebreaker of the vertical edger type and on to the roughing stands.



The last three roughing stands are of universal type, with vertical edgers integral with the mill stands.

nominal capacity of 45,000 tons per month, in coils or cut lengths, of steels ranging from low carbon up to .95 per cent carbon and 3½ per cent silicon.

HOT MILL FURNACES

There are two quadruple-fired zone controlled continuous heating furnaces installed, with space provided for a third furnace if the future should require it. They are 83 feet long overall, with an effective hearth length of 76′–10″. They are 18 feet inside width, and each is rated at 50 gross tons of cold slabs heated per hour. The furnaces are required to heat a large range of slab sizes, running 10″–42″ in width, 3″–5″ in thickness, 6–15 feet in length, and 1000 lbs.–7500 lbs. in weight. The average is about 24″ in width x 4″ thickness by 7′–10″ length, and 3600 lbs. in weight.

The furnaces are arranged with a double head pusher, so that slabs less than 8 feet in length may be heated in a double row through the furnace. For longer slabs, up to 15 or 16 feet in length, the two pusher heads may be locked together so as to operate as a single unit. Slabs are handled by slab yard cranes equipped with lifting magnets on to a magazine charger, which supplies slabs to the furnace charging table running across the backs of the furnaces. The magazine lift is driven by a 35 h.p. compound d-c motor, and the magazine chain by a 25 h.p. compound motor. The furnace charging table is sectionalized into two parts, each driven by a 50 h.p. compound motor. The double rack-type pusher on each furnace, serving to move slabs through the furnace in either single or double row, is driven by two 50 h.p. compound wound d-c motors.

The furnaces are rather unusual in design, being quadruple fired. The primary heating chamber is equipped with twelve oil burners spaced across the width of the furnace in two zones above the steel, and six similar burners spaced across the furnace below the steel. One special feature of these furnaces is the fact that the first primary zone is reverse fired—that is, in the same direction as the steel movement through the furnace—so as to place heat into the furnace where it is most desired and eliminate excessive downtake temperatures. The second primary zone and the bottom zone are both fired in the conventional way. The soaking zone is fired with eight oil burners spaced across the width of the furnace above the steel, also reverse fired, so as to eliminate as far as possible, air infiltration at the discharge doors. This system of

firing in the soaking zone is the same as that used on the 76″ strip mill furnaces in this same plant.

Through the main heating chamber, the slabs are moved on water-cooled skids, while in the soaking zone, a solid hearth built up of brickwork covered with chrome material removes the cold spots caused by the skid pipes, and allows the slab temperature to soak out evenly

Zone firing tends to reduce scale loss, permits efficient furnace operation at varying rates of production, and gives full advantage of maximum flame temperature in the primary heating chamber, at which point the steel can absorb large quantities of heat Variation in production rates is obtained by varying fuel input to the burners in the primary heating chamber in accordance with the desired operation. The soaking zone is usually held at a constant temperature and a constant firing rate.

Both furnaces are equipped with refractory tile recuperators, designed to deliver air at about 700 degrees F. at rated furnace capacity. All the air required for combustion in the main heating chamber is preheated, and is pulled through the recuperator and moved to the burners by a high temperature exhauster fan. Air for combustion in the soaking zone is supplied cold from a blower.

The fuel used is bunker C fuel oil, and with steady operation the consumption approaches 1,650,000 B.t.u. per gross ton of steel heated. The furnaces are well insulated and steel encased. Tight-closing discharge doors, which are operated by an electrically actuated mechanism, tend to reduce air infiltration. The roof, of suspended arch construction, is somewhat unusual in design, due to the plan of firing and burner location. Stack temperatures range 1000–1100 degrees F.

HOT MILL

Skid plates of special design eliminate undue shock to the roller table as the slabs, at temperatures averaging about 2250 degrees F., are discharged from the furnace by gravity, through action of the furnace pushers. The roller table, about 82 feet in length and driven in two sections by 50 h.p. compound d-c motors, conveys the slab to the hot mill, the first unit of which is a scalebreaker of vertical edger type, driven by two 300 h.p., 500 r.p.m., 440 volt, 25 cycle squirrel cage motors. Two 50 h.p., d-c motors serve for roll adjustment, through a range of 10″ to 44″. The slight edging reduction serves very effectively to crack loose scale formed in the furnace, which is then removed by hydraulic water sprays at a pressure of 1000 lb. per sq. in. Following this at a distance of 27 feet is the first roughing stand, a 2-high, 36″ x 44″ stand, driven through gears by a 2500 h.p., 6600 volt, 150 r.p.m., 25 cycle synchronous motor. As slabs are available in widths up to the maximum strip width that can be rolled on this mill, no broadside rolling is done on this mill. Hence, the usual turntables, slab pusher and slab squeezer are absent from this mill, and the first roughing stand is 2-high rather than 4-high.

The second roughing stand, which is spaced 39′–9″ farther along is a 4-high, 21½″ and 44″ x 44″ stand. No. 3 and 4 roughers, spaced on 55′–6″ and 82′–6″ centers respectively, are duplicates of the second stand. Each of these stands are driven through gears by a 2500 h.p., 6600 volt, 375 r.p.m., 25 cycle synchronous motors. Spacing of the roughing stands is such that the slab is in but one stand at a time, allowing the use of constant speed motors on these stands. The last three roughing stands are of universal type, with vertical edger rolls 22″ in diameter on the entry side, integral with the mill stand and driven by a 150 h.p., 450/900 r.p.m., compound d-c motor mounted on top of each mill stand. Edger roll adjustment is effected through 15 h.p., d-c motors. Edger roll speed is syn-

General view of the four roughing stands. A crop shear is located immediately after the last rougher (center).

chronized with main roll speed through the same control system.

A cooling table 132′–3″ long lies between the roughing and finishing trains, and is provided with water sprays in order to obtain proper strip temperature for finishing with the desired metallurgical requirements. A crop shear is installed at each end of this table, so that both front and back ends of the strip can be squared off before finishing. Each shear is driven by a 75 h.p., compound wound motor.

The finishing scalebreaker is a 2-high, 24″ x 44″ horizontal stand, driven by a 500 h.p., 150/600 r.p.m., 600 volt d-c motor. Following this at a distance of 14′–8″ is the finishing train, consisting of six 4-high 21½″ and 44″ x 44″ stands, spaced on 18 ft. centers, and each driven through gears by a 2500 h.p., 225/450 r.p.m., 600 volt, d-c motor. A looper is installed between successive finishing stands to take up any slack occurring through the finishing train. They are each driven by a 50 h.p. shunt torque motor, controlled from two special 25 k.w., 55 volt, d-c motor-generator sets located in the hot mill motor room.

Mill speeds, gear ratios, etc., through the mill are as follows:

	Gear Ratio	Roll Speed (R.P.M.)	Strip Speed Ft./Min.
No. 1 Scalebreaker	28.57	17.50	183.3
No. 1 Rougher	7.80	19.23	181.2
No. 2 Rougher	7.80	48.08	270.6
No. 3 Rougher	5.47	68.56	385.9
No. 4 Rougher	5.47	68.56	385.9
No. 2 Scalebreaker	8.81	17.03/68.12	107/428
No. 5 Finisher	5.875	38.30/76.60	216/431
No. 6 Finisher	3.46	65.03/130.1	366/732
No. 7 Finisher	2.38	95.54/191.08	538/1076
No. 8 Finisher	1.84	122.3/244.6	688/1376
No. 9 Finisher	1.50	150/300	844/1688
No. 10 Finisher	1.27	177/354	997/1994

Screwdown drives are mounted on top of the mill housings. Two 35 h.p. compound motors are used on each of the 4-high stands. Individual adjustment may be made on each screw on these mills, or the two motors may be used in unison, connected through a magnetic clutch of 16″ in diameter. A single 25 h.p., d-c motor drives the screwdown on the 2-high rougher, and a 15 h.p. motor serves the finishing scalebreaker screwdown.

The various auxiliary drives are largely mill type d-c motors, with magnetic control equipment. The control panels were completely assembled at the factory with the necessary busses, resistors, etc., and were shipped complete.

Immediately following the last finishing stand is a flying shear, which can gauge lengths from 11 feet to 22 feet, or can be used to crop front and rear ends of the trip. It is driven by two 150 h.p., 450 r.p.m. shunt motors which are controlled through a hydraulic drive geared to the last finishing stand. Shear speed is thus synchronized with the speed of the last finishing stand. The motors operate by voltage control up to 1250 r.p.m., 600 volts, and draw their power from a 500 k.w., 600 volt, d-c generator. Strip speed runs as high as 2,000 ft. per min., and the speed of the shear knives is adjustable up to 4000 ft. per min.

Approximately 333 feet further along the run-out table are located two hot coilers. Each coiler employs the following motors:

Roll drive—Four 10 h.p., 1200 r.p.m. shunt motors.
Guide roller drive—One 10 h.p., 1200 r.p.m. shunt motor.
Pinch roll drive—One 35 h.p., 575/1200 r.p.m. shunt motor.
Coil feed drive—One 20 h.p., 1500 r.p.m. 440 volt a-c motor.
Spring adjustment—One 7½ h.p., 900 r.p.m. compound motor.
Pinch roll adjustment—One 3 h.p., 750 r.p.m. 440 volt a-c motor.

The first three items receive power from special motor-generators, while the last three are supplied from the general plant services. Coils are removed from the coilers by air operated ejectors, manually controlled and so interlocked as to be inoperable except when coiler rolls are in full open position.

From the coilers, coils are moved to the coil storage by a link chain type conveyor, sectionalized at four

points. Each section is driven by a 35 h.p., 230 volt d-c motor. At one point this conveyor makes a 90 degree bend, where individually driven rollers keep the coil moving around the bend. These rollers are driven by nine ½ h.p., 500 r.p.m., 440 volt a-c motors, which receive their power from a special generator. The generator is driven by one of the chain conveyor drive motors, thus holding the bend at the same speed as the main conveyor. At the end of the chain type conveyor a 180 degree bend leads to a roller type conveyor running in the opposite direction, allowing additional time for the coils to cool.

The runout table proceeds on past the coilers for a distance of about 210 feet, to a piler which handles cut lengths from the mill.

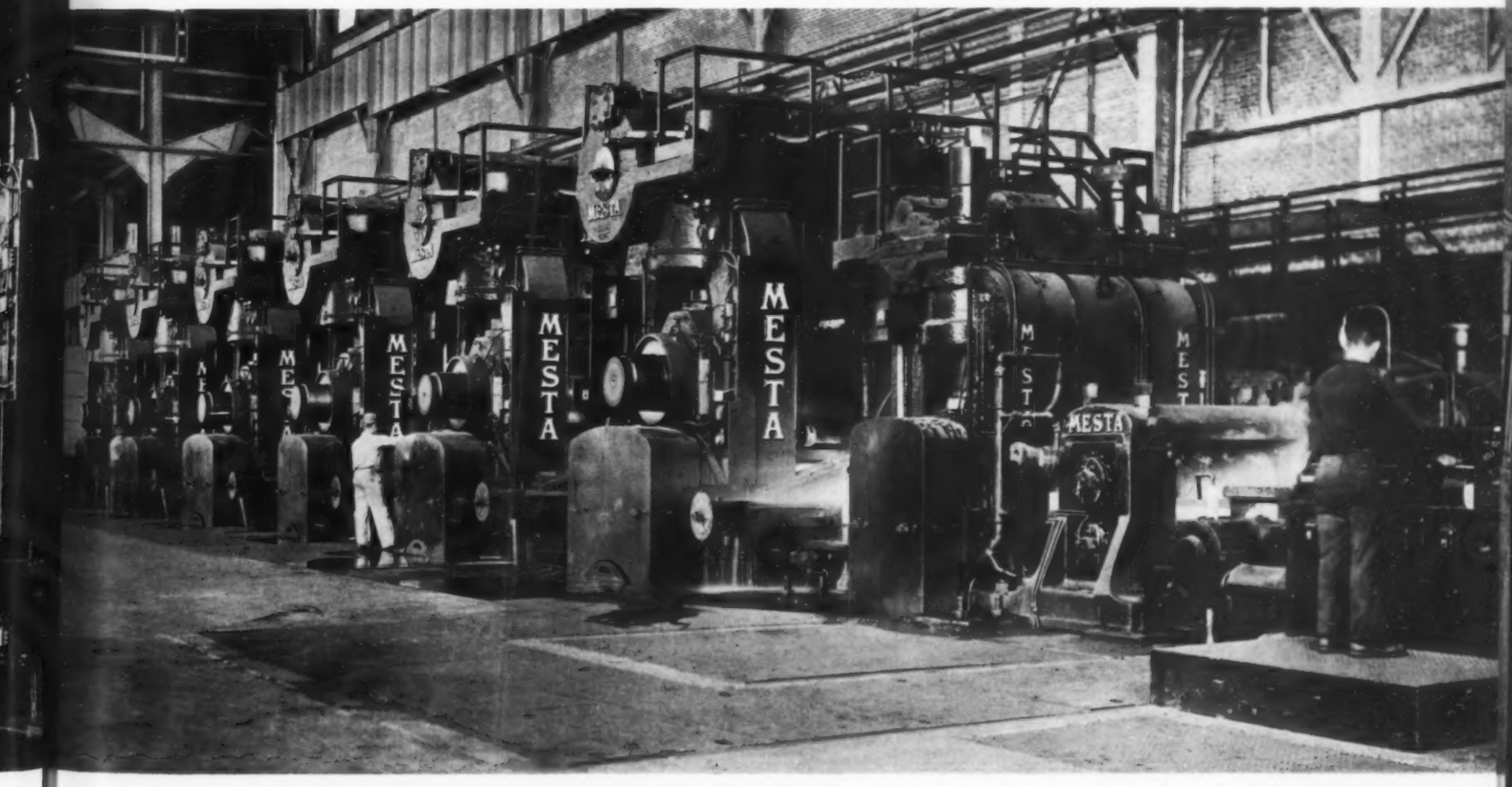
Mill tables through the roughing train are driven through line shafts and bevel gearing by 35 h.p., 575 r.p.m., 230 volt d-c compound motors. The delay table between the roughing and finishing trains is composed of seventy-two rollers, driven in pairs by thirty-six 2 h.p., 525 r.p.m., 250 volt, d-c shunt wound flange mounted motors, which receive their power from a special motor generator set. The mill runout table to the coilers and on to the piler is also made up of rollers driven in pairs, each pair by a single motor. These motors aggregate one hundred and eighty-one 7½ h.p., 1725 r.p.m., flange mounted, and eight 3 h.p., 510 r.p.m. ceiling mounted motors, all of 250 volts d-c shunt wound, receiving power from a special motor generator set, and controlled through a Ward-Leonard system. All table rolls are of chilled cast iron rollers which steel shafts, and are ground smooth to avoid marring the strip surface. They are spaced on 18″ centers.

Roll assemblies in the hot mill stands are balanced by an oil-hydraulic pressure system with an accumulator and a motor-driven oil pressure pump.

Hydraulic sprays for descaling are located at stands No. 1, No. 2, No. 3, No. 4, No. 2 scalebreaker, and at No. 10 stand. Water is furnished to these sprays at 1000 lb. per sq. in. pressure by a multi-stage 1000 g.p.m. centrifugal pump, driven by an 800 h.p., 730 r.p.m. 2200 volt a-c motor. This pump is located in a new pump house laying just south of the 44″ strip mill. The valves controlling these sprays are located along the wall of the hot mill building, and are operated from limit switches located in front of each spray. The approaching steel actuates the limit switch, which is connected electrically to a solenoid air valve which in turn controls the operation of the hydraulic valve. A time-limit relay prevents closing of the spray valve until a pre-determined time interval has elapsed after the steel has cleared the limit switch. A by-pass is provided around each hydraulic valve to allow enough water to fill piping and sprays to flow at all times, thus eliminating water hammer from the sudden operation of the hydraulic valve.

Steam jets for scale and dirt removal are located at each stand, and are controlled in the same way as the hydraulic sprays, except that a manual control is pro-

Views of the finishing train, which is made up of a scale-breaker and six four-high finishing stands, immediately preceeded by a crop shear.



LUBRICATION DATA—OIL SYSTEMS

Number	Type	Storage Capacity (Gal.)	Rate of Circul. (G.P.M.)	Oil Viscosity Saybolt Universal	Equipment Served
1	Automatic pressure	2,000	32	2200–2400 sec. @ 100 deg. F.	Vertical Edger roll stand.
1	Automatic pressure	24,000	350	2200–2400 sec. @ 100 deg. F.	Back-up roll bearings
1	Automatic pressure	12,000	225	2500–2600 sec. @ 100 deg. F.	Pinion stand bearings.
1	Automatic pressure	10,000	225	1600–1700 sec. @ 100 deg. F.	Mill drive reduction gear sets.

GREASE SYSTEMS

Number	Type	Grade of Grease	Number of Points Served	Equipment Served
5	Central pressure	Roller Bearing Grease	2090	Work roll bearings. Table roll bearings.

vided at the operators pulpit so as to allow selective segregated operation of the steam sprays.

LUBRICATION

Four automatic circulating oil systems serve to lubricate the hot mill; one for the vertical edger stand; one for the back-up roll bearings, which are equipped with oil-flooded bearings; one for the bearings on the mill pinion stands; and one for the mill drive reduction gear sets. Capacities and types of oil used in these systems are given in the accompanying table. These systems include the necessary storage tanks, pumps, coolers, filters, alarms, etc., and are so interlocked with mill control as to render the mill inoperative unless oil pressure is satisfactory. Work rolls throughout the mill are equipped with roller bearings. Lubrication of these bearings, as well as the table rolls which also run in anti-friction bearings, is provided by five central grease systems, which serve a total of 2090 separate points of lubrication.

HOT MILL MOTOR ROOM

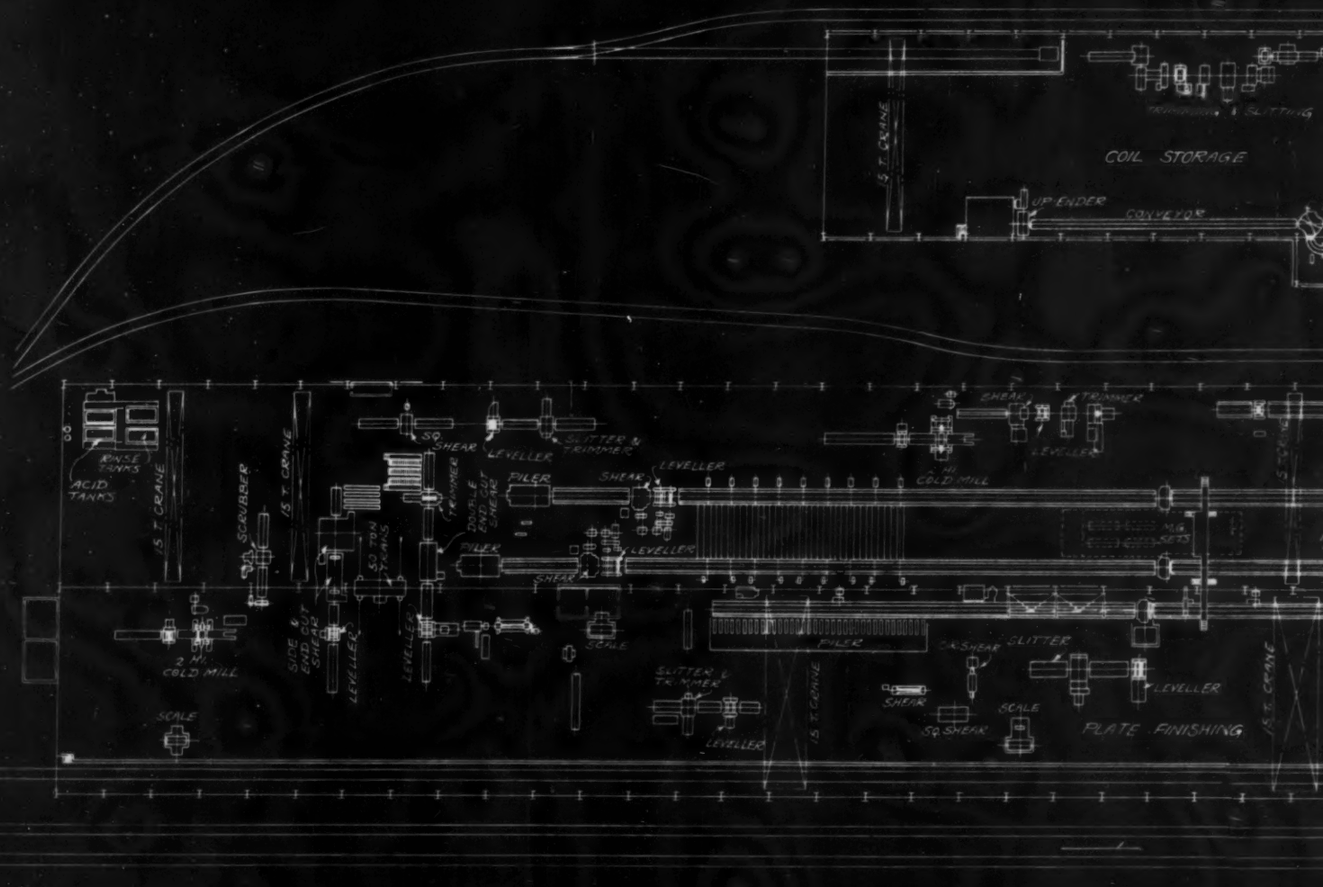
The motor room, which is 530 ft. long x 54′–4½″ wide, parallels the hot mill, and lays between the hot mill building and the slab yard. In it are housed the main mill drive motors previously described, together with their reduction gear sets, switching equipment, etc. The roughing stand motors are all 6600 volt constant speed synchronous motors, controlled from the roughing pulpit. All finishing mill motors are 600 volt, d-c variable-speed shunt wound motors. They are controlled from the finishing pulpit, and their speed is controlled through motor-driven rheostats and hand-operated vernier rheostats. The motors are started simultaneously by the Ward-Leonard reduced voltage system, and are brought up to speed by raising generator voltage, but operate at a pre-determined constant voltage, with speed adjustment made by adjustment of motor field current.

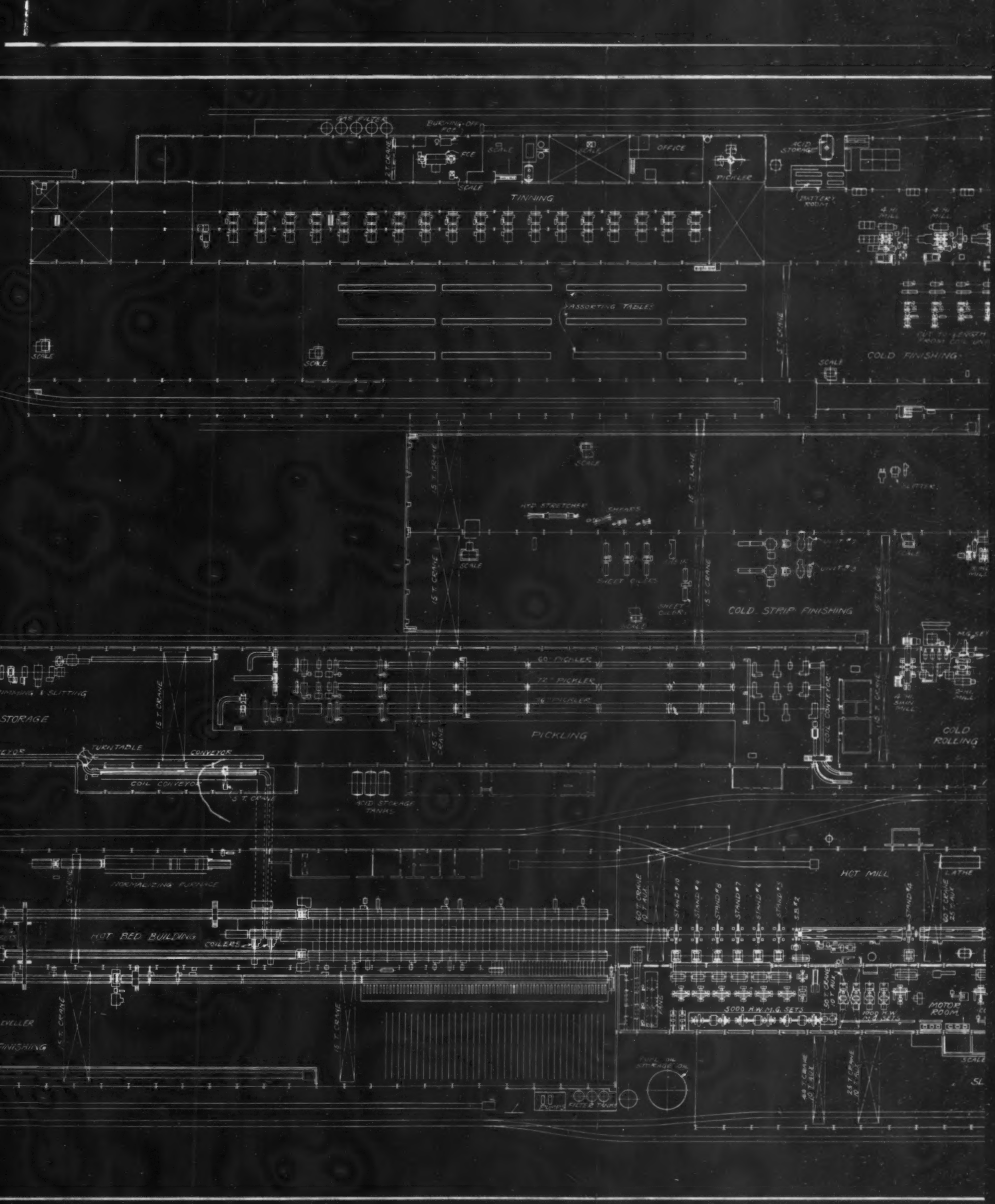
Finishing mill motors draw power from two motor-generator sets, each consisting of two 2500 k.w., 600 volt d-c generators, one 1000 k.w., 250 volt d-c generator, and one 500 k.w. exciter, all driven by one 10,000 h.p., 6600 volt, 25 cycle synchronous motor. The 1000 k.w. 250 volt generators in these sets supply general plant d-c power for various auxiliaries. The 2500 k.w. generators operate in parallel to supply the finishing train power. Two exciter control generators are used in connection with the six 2500 h.p., finishing stand drives. Each consists of three 20 k.w., 1200 r.p.m., 250 volt shunt wound d-c generators.

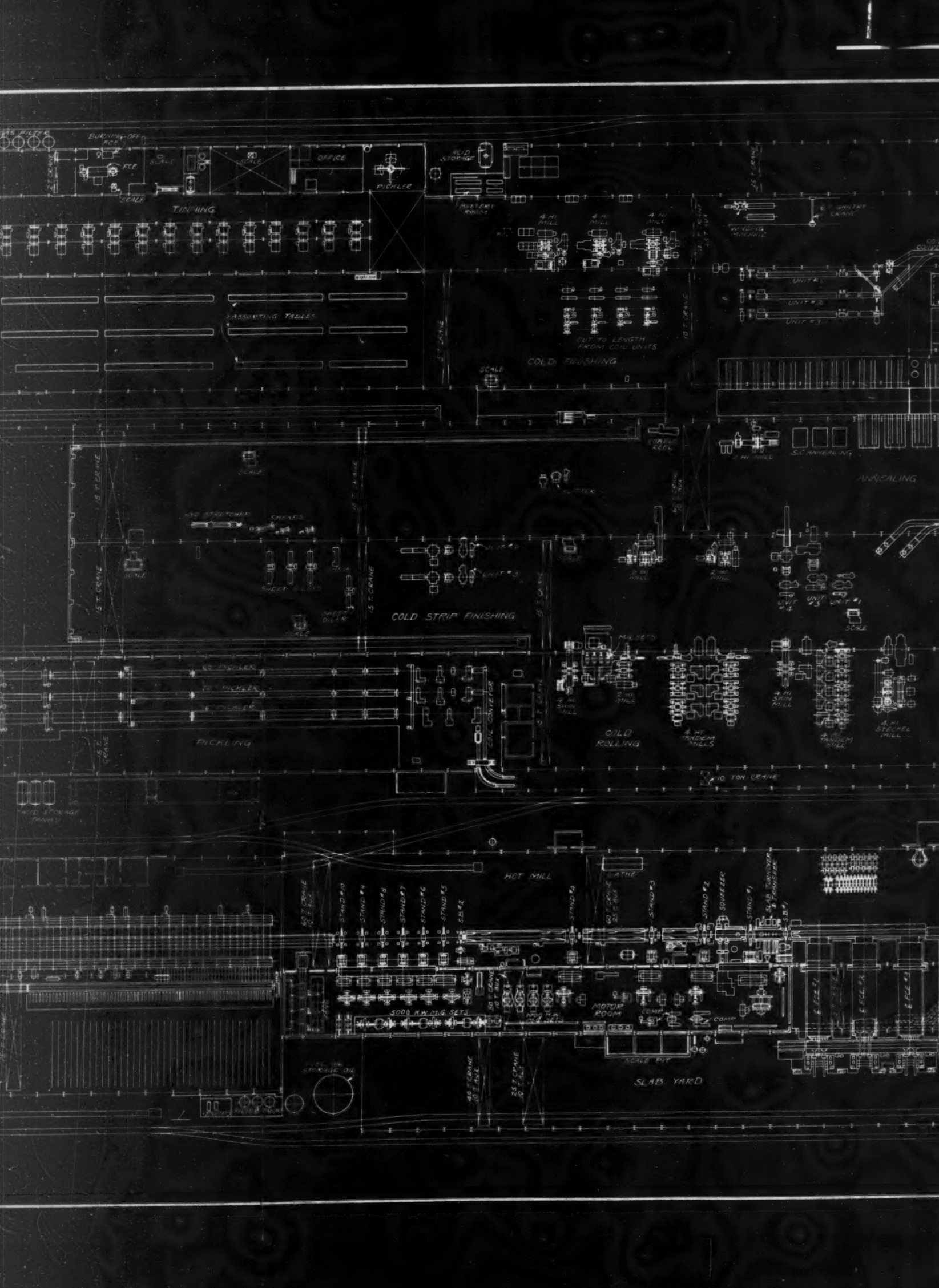
Also housed here is a special motor generator set for the Ward-Leonard control system used on the run-out table motors, coilers, etc. This set consists of five 250 k.w., 250 volt d-c generators driven at 750 r.p.m. by a 1250 h.p., 6600 volt, 25 cycle synchronous motor. This set is also self-excited.

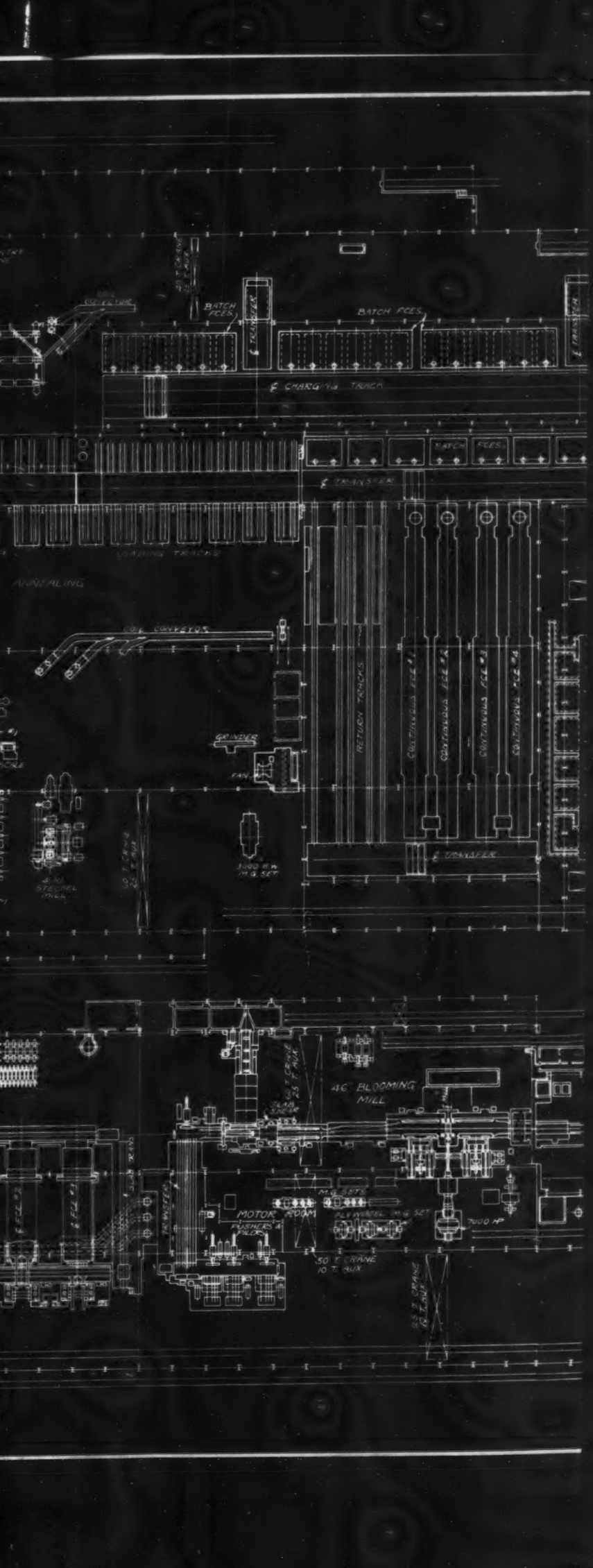
A small motor generator set for driving the cooling or delay table is located between the main drive motors for stands No. 3 and No. 4, and consists of two 30 k.w.,

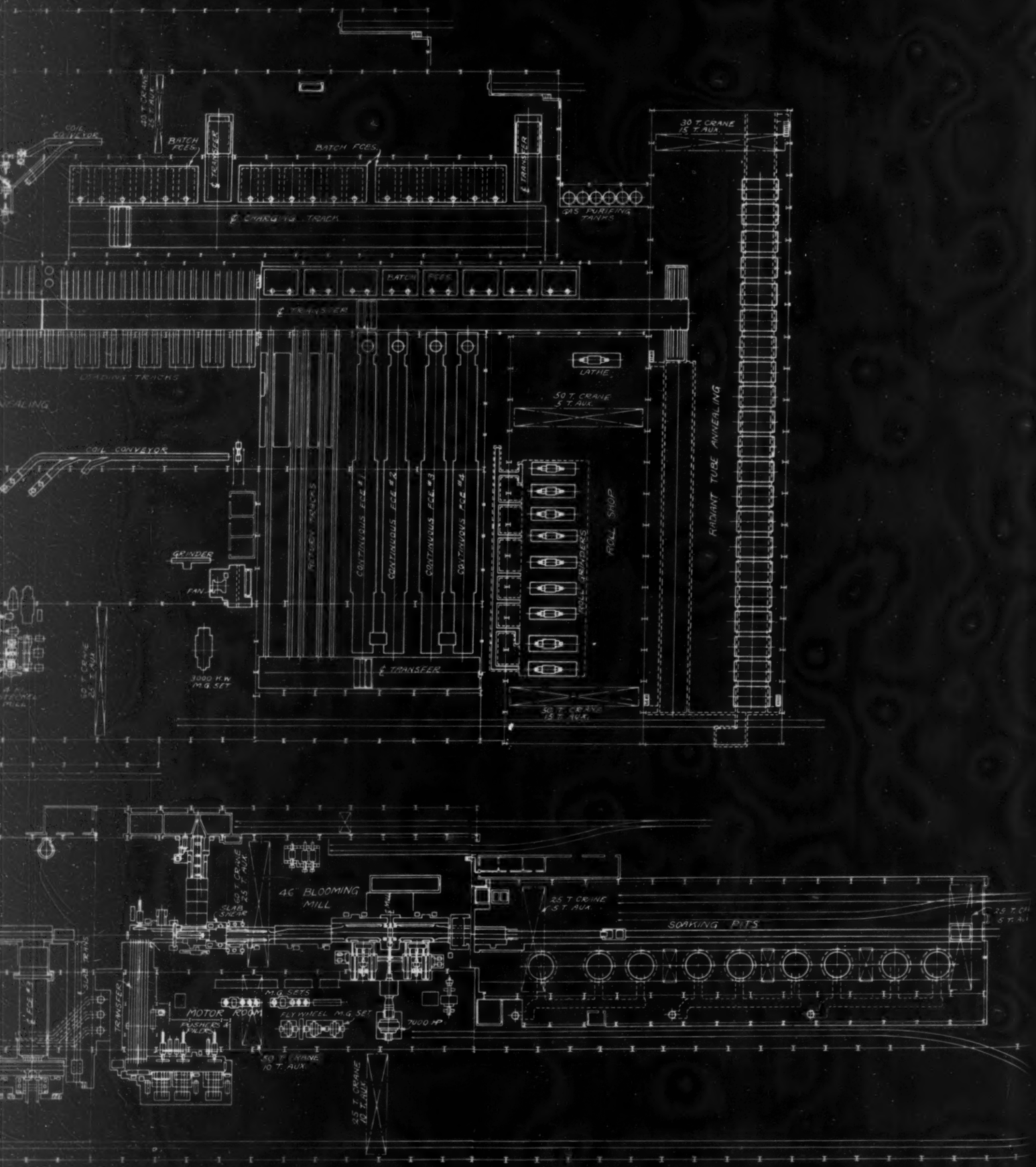
PLAN VIEW
STRIP & TIN MILLS
INLAND STEEL COMPANY
INDIANA HARBOR, INDIANA




BURNING-OFF FOR
OFFICE
ACID STORAGE
PICKLER
TINNING
ASSORTING TABLES
SCALE
COLD FINISHING
CUT TO LENGTH FROM COIL LINE
SHEARS
SHEET PILES
COLD STRIP FINISHING
60 PICKLERS
72" PICKLER
36" PICKLER
PICKLING
COIL CONVEYOR
TURNTABLE
CONVEYOR
ACID STORAGE TANKS
COLD ROLLING
NORMALIZING FURNACE
HOT BED BUILDING
COILERS
HOT MILL
STAND #10
STAND #9
STAND #8
STAND #7
STAND #6
STAND #5
STAND #4
5000 H.P. D.C.G. SETS
1000 H.P. D.C.G. SETS
MOTOR ROOM
LATHE
FUEL OIL STORAGE OIL
FILTER ROOM
60 T. CRANE 10 T. AUX.
25 T. CRANE 10 T. AUX.
15 T. CRANE


GAS FILTERS
BURNING OFF
FCE
SCALE
OFFICE
PICKLER
ACID STORAGE
TINNING
ASSORTING TABLES
4 HI MILL
4 HI MILL
4 HI MILL
CUT TO LENGTH FROM COIL UNITS
COLD FINISHING
UNIT #1
UNIT #2
UNIT #3
S.C. ANNEALING
ANNEALING
1ST CRANE
SCALE
HOT STRETCHER
SHEARS
SHEET SHEARS
SCRAP CUTTER
COLD STRIP FINISHING
2 HI MILL
2 HI MILL
UNIT #4
UNIT #3
UNIT #2
UNIT #1
M.G. SETS
4 HI SKIN MILL
2 HI SKIN MILL
4 HI TANDEM MILLS
4 HI SKIN MILL
4 HI TANDEM MILL
4 HI STEEL MILL
COIL CONVEYOR
PICKLING
COLD ROLLING
10 TON CRANE
ACID STORAGE TANKS
HOT MILL
STAND #10
STAND #9
STAND #8
STAND #7
STAND #6
STAND #5
STAND #4
STAND #3
STAND #2
SQUEEZER
STAND #1
5000 K.W. C.I.G. SETS
MOTOR ROOM
COMP
SCALE PIT
SLAB YARD
40 T CRANE
25 T CRANE


BATCH PCES.
E. TRANSFER
E. CHARGING TRACK
BATCH PCES.
E. TRANSFER
COOLING TRACKS
ANNEALING
COIL CONVEYORS
RETURN TRACKS
CONTINUOUS FEED
CONTINUOUS FEED
CONTINUOUS FEED
CONTINUOUS FEED
GRINDER
FAN
3000 H.P. M.G. SET
40" STEEL MILL
50 T. CRANE 25 T. AUX
40" BLOOMING MILL
SLAB SHEAR
M.G. SETS
MOTOR ROOM
PUSHERS & TILTER
FLY WHEEL M.G. SET
7000 HP
50 T. CRANE 10 T. AUX
25 T. CRANE 10 T. AUX
TRANSFER


COIL CONVEYOR
BATCH FCES.
TRANSFER
BATCH FCES.
TRANSFER
30 T. CRANE 15 T. AUX.
CHARGING TRACK
GAS PURIFING TANKS
BATCH FCES.
TRANSFER
LOADING TRACKS
LATHE
50 T. CRANE 5 T. AUX.
COIL CONVEYOR
GRINDER
FAN
ROTARY FURNACES
CONTINUOUS FCE. #1
CONTINUOUS FCE. #2
CONTINUOUS FCE. #3
CONTINUOUS FCE. #4
ROLL SHOP
ROLL GRINDERS
RADIANT TUBE ANNEALING
3000 H.P. M.G. SET
TRANSFER
50 T. CRANE 15 T. AUX.
25 T. CRANE 25 T. AUX.
25 T. CRANE 25 T. AUX.
46" BLOOMING MILL
SLAB SHEAR
25 T. CRANE 25 T. AUX.
SOAKING PITS
28 T. CR 5 T. AU
SLAB TRANS.
TRANSFER
M.G. SETS
MOTOR ROOM
PUSHERS & PILERS
FLYWHEEL M.G. SET
7000 HP
50 T. CRANE 10 T. AUX.
25 T. CRANE 10 T. AUX.

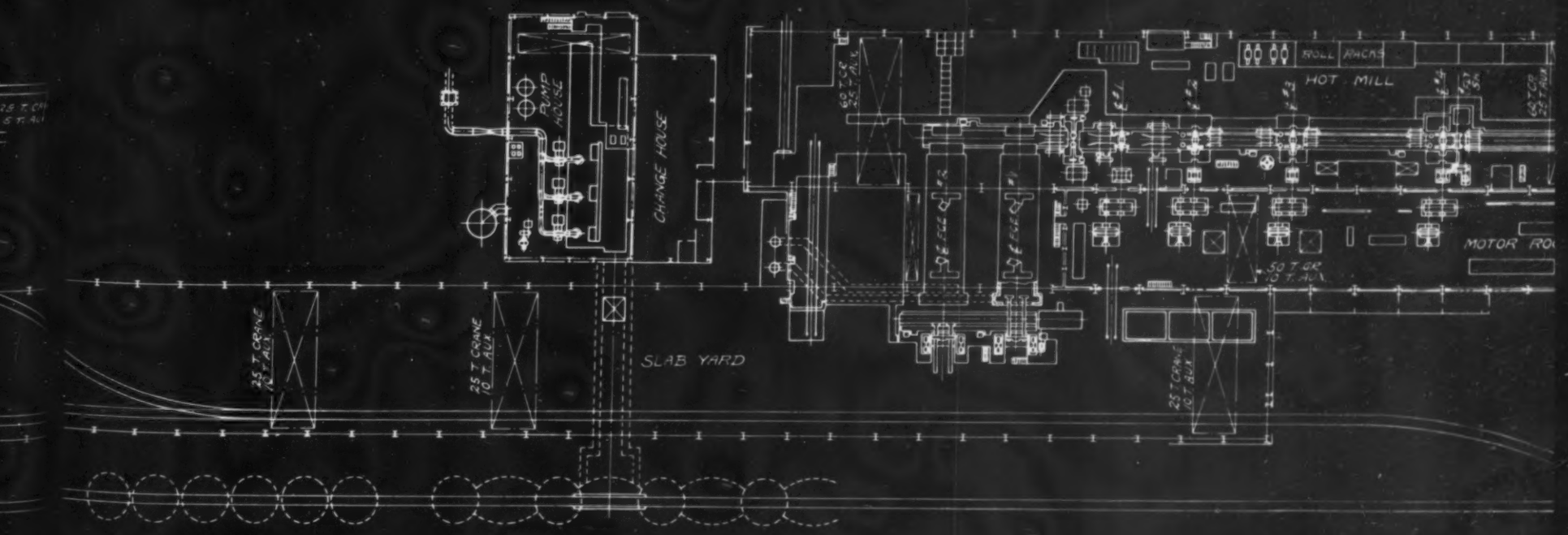
Mill D

76" HOT MILL

Stand	Characteristics	Roll Diameter		Roll Length	Motor				Remarks
		Work Roll	Back-up Roll		H.P.	Volts	R.P.M.	Type	
Scale Breaker	1-Stand, 2-High	23"		76"	1000	6600	375	Wound rotor ind.	Geared.
Broadside	1-Stand, 4-High	36"	49"	95"	3000	6600	150	Wound rotor ind.	Geared. Flywheel.
No. 2 Rougher	1-Stand, 4-High	24½"	49"	77"	3000	6600	300	Wound rotor ind.	Geared. Flywheel.
No. 3 Rougher	1-Stand, 4-High	24½"	49"	77"	3000	6600	300	Wound rotor ind.	Geared. Flywheel.
No. 4 Rougher	1-Stand, 4-High	25"	49"	77"	3000	6600	300	Wound rotor ind.	Geared. Flywheel.
Scale Breaker	1-Stand, 2-High	24"		76"	500	600	150/450	D. C.	Geared.
No. 5 Finisher	1-Stand, 4-High	24½"	49"	77"	3500	600	175/350	D. C.	Geared.
No. 6 Finisher	1-Stand, 4-High	24½"	49"	77"	3500	600	175/350	D. C.	Geared.
No. 7 Finisher	1-Stand, 4-High	24½"	49"	77"	3500	600	175/350	D. C.	Geared.
No. 8 Finisher	1-Stand, 4-High	24½"	49"	77"	3500	600	175/350	D. C.	Geared.
No. 9 Finisher	1-Stand, 4-High	24½"	49"	77"	3500	600	175/350	D. C.	Geared.
No. 10 Finisher	1-Stand, 4-High	24½"	49"	77"	3500	600	175/350	D. C.	Geared.

COLD MILLS

Tandem Mill	4-Stands, 4-High	20"	44"	54"	(1—500 1—750 (1—800 1—1250	600	400/800	D. C.	With reel. Geared.
Tandem Mill	3-Stands, 4-High	20"	44"	72"	3/1250	600	400/800	D. C.	With reel. Geared.
Cold Mill	1-Stand, 4-High	20"	44"	72"	350	600	400/800	D. C.	With reel. Geared.
Cold Mill	1-Stand, 4-High	20"	44"	72"	350	600	400/800	D. C.	With reel. Geared.
Cold Mill	1-Stand, 2-High	27"		54"	60/125	250	225/900	D. C.	With reel. Geared.
Cold Mill	1-Stand, 2-High	27"		54"	60/125	250	225/900	D. C.	With reel. Geared.
Stecked Mill	1-Stand, 4-High	12"	34"	39"	1000	600	400/800	D. C.	Geared to working rolls
Planish Mill	1-Stand, 4-High	18"	39"	42"	250	250	850/1400	D. C.	With reel. Geared.
Planish Mill	1-Stand, 4-High	18"	39"	42"	250	250	850/1400	D. C.	With reel. Geared.
Tandem Mill	5-Stands, 4-High	18"	49"	40"	(3)750 (2)500	750	400/800	D. C.	With reel. Geared.


PUMP HOUSE
CHANGE HOUSE
SLAB YARD
HOT MILL
ROLL RACKS
MOTOR RO
25 T. CRANE 10 T. AUX.
25 T. CRANE 10 T. AUX.
50 T. CR 10 T. AUX.
25 T. CRANE 10 T. AUX.
60 T. CR 25 T. AUX.
60 T. CR 25 T. AUX.

Mill Data

COLD MILLS - Continued

Stand	Characteristics	Roll Diameter		Roll Length	Motor			
		Work Roll	Back-up Roll		H.P.	Volts	R.P.M.	Type
Cold Mill	1-Stand, 2-High	29"		78"	200	440	730	A. C.
Cold Mill	1-Stand, 2-High	29"		78"	200	440	730	A. C.
Cold Mill	1-Stand, 2-High	30"		80"	200	440	730	A. C.
Cold Mill	1-Stand, 4-High	20"	44"	72"	200	600	400/800	D. C.
Cold Mill*	1-Stand, 2-High	27"		54"	125	230	250/900	D. C.
Cold Mill*	Tension Reel				125	230	250/900	D. C.

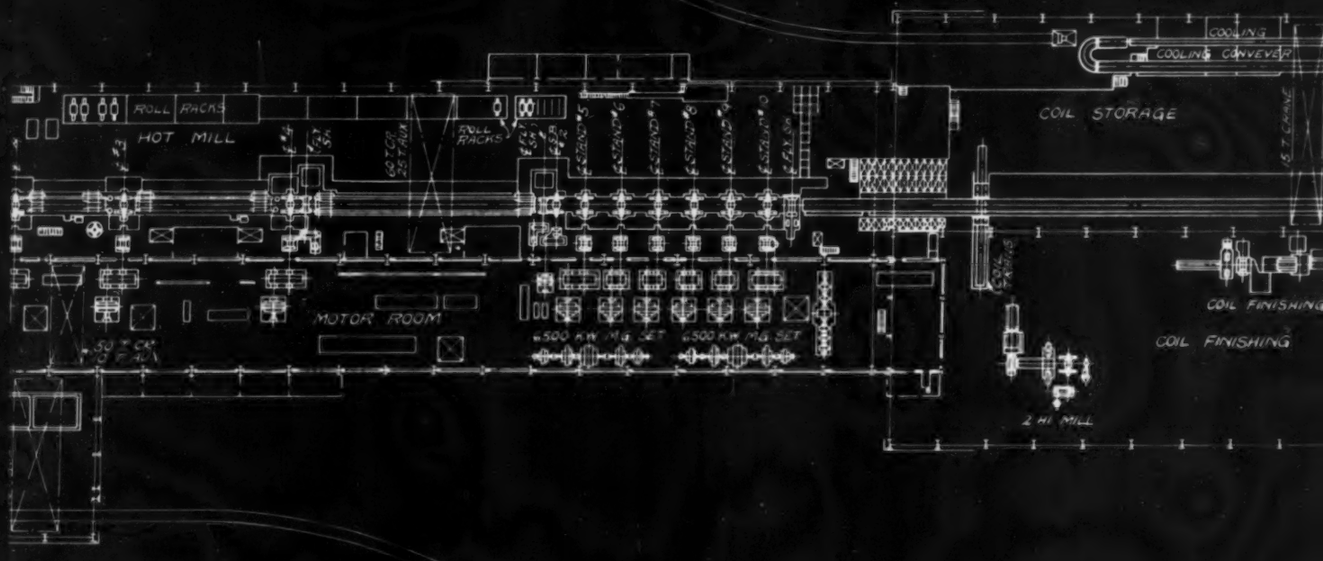
*(Located at 44" mill.)

ype	Remarks
otor ind.	Geared.
otor ind.	Geared. Flywheel.
otor ind.	Geared. Flywheel.
otor ind.	Geared. Flywheel.
otor ind.	Geared. Flywheel.
C.	Geared.
C.	Geared.
C.	Geared.
C.	Geared.
C.	Geared.
C.	Geared.
C.	Geared.

44" HOT MILL

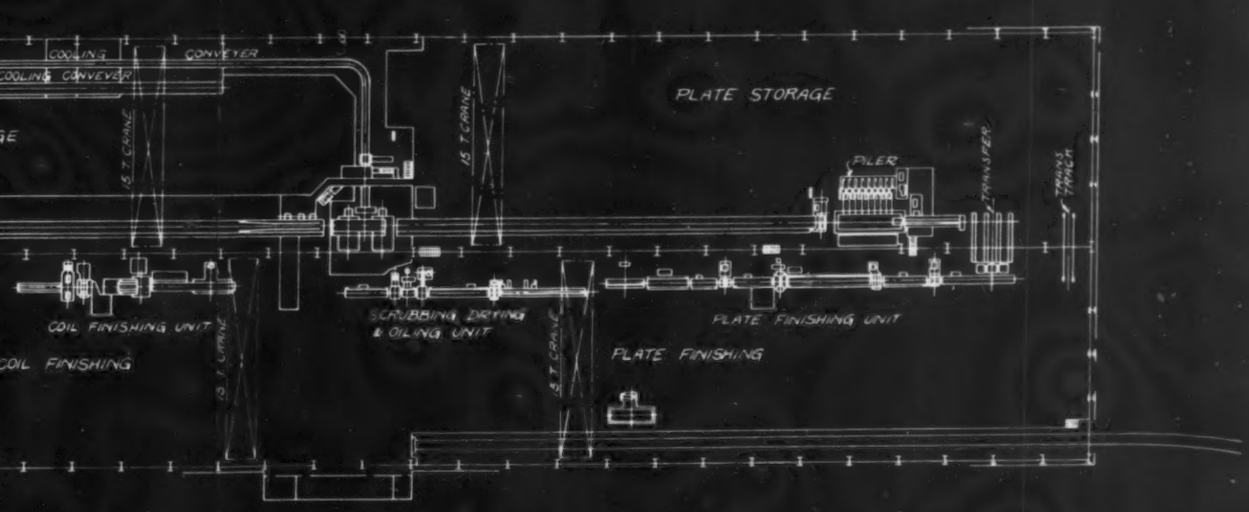
Stand	Characteristics	Roll Diameter		Roll Length	Motor			
		Work Roll	Back-up Roll		H.P.	Volts	R.P.M.	Type
Scalebreaker	Vertical Edger				(2)300	440	500	Induction
No. 1 Rougher	1-Stand, 2-High	36"		44"	2500	6600	150	Synchron.
No. 2 Rougher	1-Stand, 4-High	21½"	44"	44"	2500	6600	375	Synchron.
No. 3 Rougher	1-Stand, 4-High	21½"	44"	44"	2500	6600	375	Synchron.
No. 4 Rougher	1-Stand, 4-High	21½"	44"	44"	2500	6600	375	Synchron.
Scalebreaker	1-Stand, 2-High	22"		44"	500	600	150/600	D. C.
No. 5 Finisher	1-Stand, 4-High	21½"	44"	44"	2500	600	225/450	D. C.
No. 6 Finisher	1-Stand, 4-High	21½"	44"	44"	2500	600	225/450	D. C.
No. 7 Finisher	1-Stand, 4-High	21½"	44"	44"	2500	600	225/450	D. C.
No. 8 Finisher	1-Stand, 4-High	21½"	44"	44"	2500	600	225/450	D. C.
No. 9 Finisher	1-Stand, 4-High	21½"	44"	44"	2500	600	225/450	D. C.
No. 10 Finisher	1-Stand, 4-High	21½"	44"	44"	2500	600	225/450	D. C.

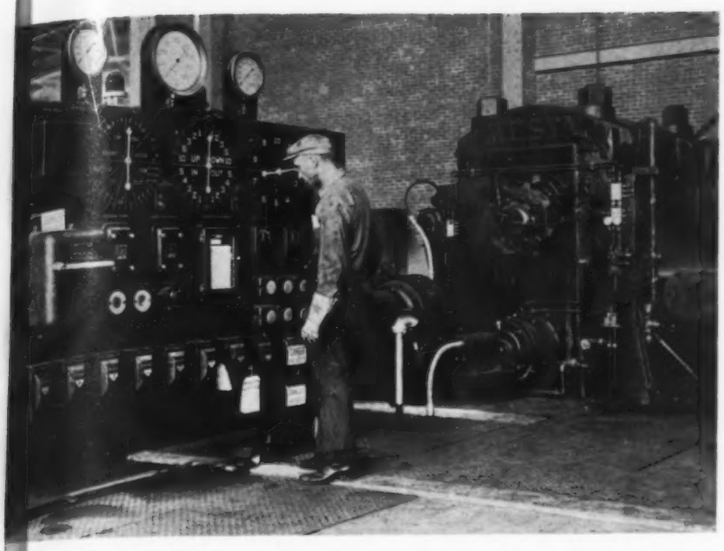
C.	With reel. Geared.
C.	With reel. Geared.
C.	With reel. Geared.
C.	With reel. Geared.
C.	With reel. Geared.
C.	With reel. Geared.
C.	Geared to working rolls
C.	With reel. Geared.
C.	With reel. Geared.
C.	With reel. Geared.
C.	With reel. Geared.



	Motor	
	Type	Remarks
	A. C.	Geared.
	A. C.	Geared.
	A. C.	Geared.
	D. C.	Geared.
	D. C.	Geared.
	D. C.	Geared.

	Motor	
	Type	Remarks
	Induction	Geared.
	Synchron.	Geared.
	Synchron.	Geared.
	Synchron.	Geared.
	Synchron.	Geared.
	D. C.	Geared.
	D. C.	Geared.
	D. C.	Geared.
	D. C.	Geared.
	D. C.	Geared.
	D. C.	Geared.
	D. C.	Geared.





On this panel board, located at the flying shear, are selsyn signals from the coilers and piler, temperature records, and various controls.

250 volt d-c generators driven by a 75 h.p., 440 volt, 1500 r.p.m. induction motor.

There are also two motor generator sets supplying the looper motors. Each set is made up of a 25 k.w., 55/230 volt d-c generator, and a 40 h.p., 440 volt, 1450 r.p.m. induction motor.

Metal-clad switchgear has been supplied to take care of 6600 volt incoming feeders, roughing mill motors, motor-generator sets for finishing mill stands and auxiliary power. This switching equipment includes oil blast circuit breakers with 500,000 Kva. interrupting capacity. The equipment was completely assembled at the factory and shipped complete with instruments and relays mounted on the front doors of the metal-clad enclosures, thereby minimizing cost and labor involved in erection. This same plan was followed for control panels of auxiliary d-c and a-c circuits. All of these latter circuits are equipped with automatic reclosing air circuit breakers.

Electrical machinery in the motor room is cooled by drawing air from the motor room down through the units, from where it passes through surface type air coolers and is discharged back into the motor room by blowers, and recirculated. Make-up air is taken from the outside through an air filter by a 40,000 c.f.m. motor driven fan, and is discharged directly into the motor room. Provision has been made for the future installation of an air cooler on this make-up air. This type of ventilating system, in which cool air is discharged into the motor room, affords a cool room at advantageous cost, while simultaneously keeping the machines clean and cool.

This mill has a unique feature in the use of d-c motors to drive coilers and runout table rollers, rather than the conventional variable frequency system. It is one of the three latest strip mills which have employed this system. The motors are divided into groups, each group being supplied with power from a d-c generator. Ward-Leonard control is used, and a section of table is started and stopped entirely by voltage control by operating on the field of the d-c generator. Fast acceleration is obtained, thus aiding in the start-stop duty, while the smooth application of the torque reduces shock on the mechanical parts. Other advantages are the elimination of the extra conversion loss entailed in the variable frequency system, elimination of rotor losses of squirrel cage motors, simplification of control equipment, and saving of sub-station space. This question of a-c vs. d-c for coiler and runout table drives has been widely discussed, and the two types of systems will be closely watched with considerable interest.

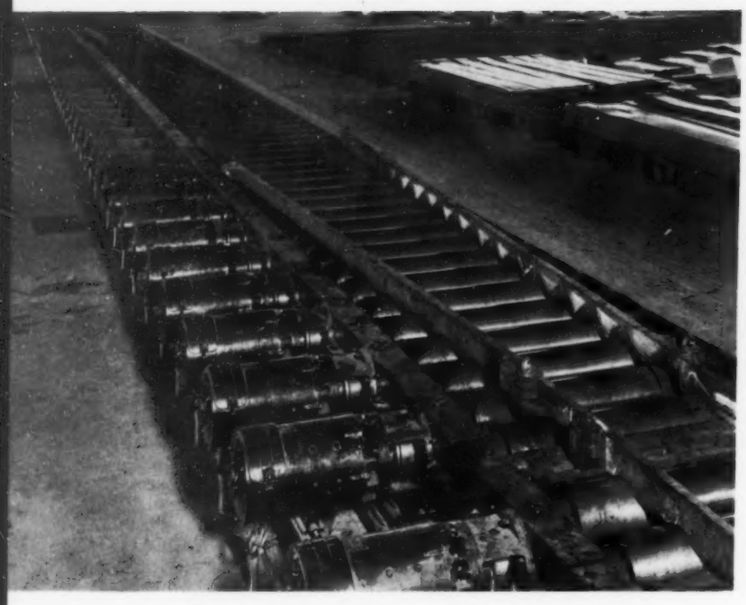
Power is supplied to the 44″ mill directly from the plant power house at 6600 volts, 25 cycles. A transformer house located just outside the hot mill motor room houses the following:

One 200 kva. single phase, 6600/230 volt lighting transformer.

Two banks, each of three transformers,, 500 kva. single phase 6600/440 volts, for auxiliary power.

Two 1667 kva. single phase 6600/2200 volt trans-

Two coilers of the latest design produce uniform, tightly wound coils, insuring a better annealed product.



The mill runout table is made up of rollers driven in pairs, each pair by a single d.c. motor.

formers, supplying 2200 volt power for the pump-house.

FINISHING EQUIPMENT

The finishing department of the 44″ strip mill is equipped only for hot-rolled finishing. Any product from this mill intended for cold finishing is transferred to the Cold Mills, where a very complete finishing layout is provided, including the following equipment:

One 60″ continuous pickling line.
One 72″ continuous pickling line.
One 76″ continuous pickling line.
One 4-stand, 4-high 54″ tandem mill.
One 3-stand, 4-high 72″ tandem mill.
Three single stand, 4-high 72″ cold mills.
One single stand, 2-high 54″ cold mill.
Four single stand, 4-high 42″ planish mills.
One single stand, 4-high 39″ Steckel mill.
One 5-stand, 4-high 40″ tandem mill.
One single stand, 2-high 73″ cold mill.
Four continuous tunnel type annealing furnaces.
Thirty-four batch type annealing furnaces.
Eight radiant tube type annealing covers and 28 bases.

This equipment, together with the necessary cutting and trimming lines, provides adequate finishing capacity to take care of both hot strip mills. A complete description of this equipment appeared in the IRON AND STEEL ENGINEER for September, 1937.

The hot-rolled finishing equipment installed for the 44″ strip mill includes one single stand two-high 27″ x 54″ cold mill used for skin rolling of coils, and driven by a 125 h.p. 250/900 r.p.m., 230 volt d-c motor. The motor is operated through Ward-Leonard control, and receives power from two motor-generator sets, each consisting of a 125 kw., 250 volt d-c generator driven by a 200 h.p., 440 volt a-c motor. These M. G. sets are located in the extreme north end of the hot mill motor room. The mill is equipped with tapered roller bearings, grease lubricated, and is driven through a reduction gear set so as to obtain a roll speed of 145/522 r.p.m. The tension reel for this mill is driven by a motor duplicating that of the mill drive, while the feed reel is equipped with two 25 kw. drag generators. A coil transfer serves to bring coils from the adjacent storage building into the finishing department.

Other equipment in this department includes the following:

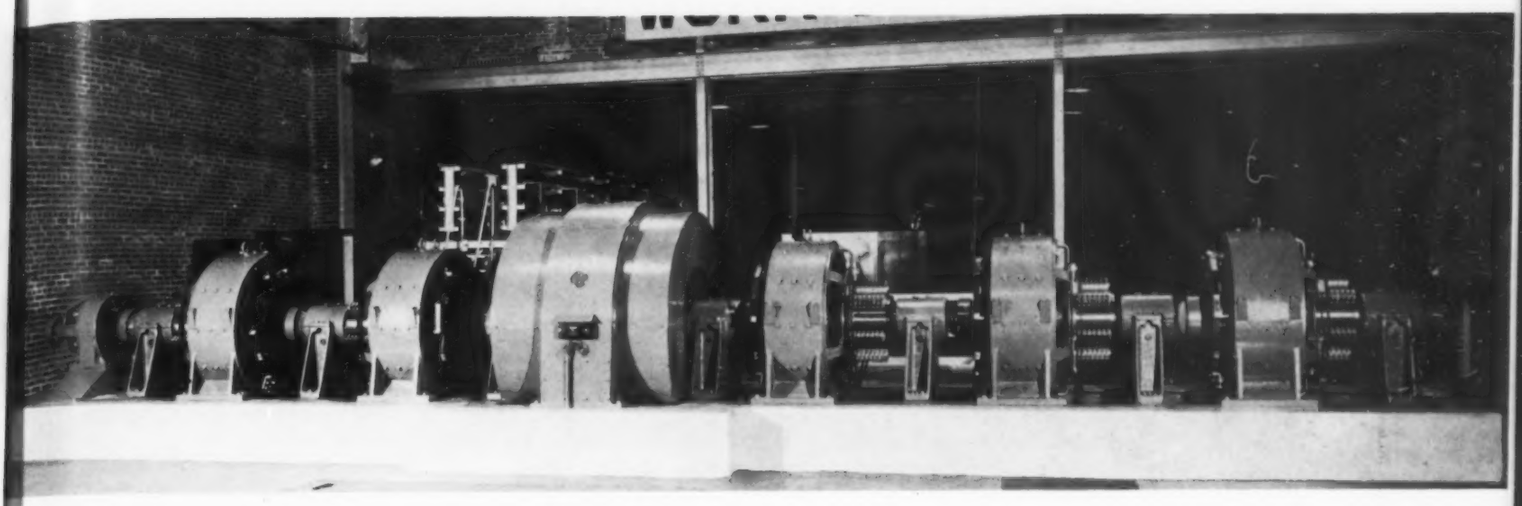
One coil finishing unit for shearing coils to lengths of 4 to 20 feet. This unit consists of a feed reel, side

SUMMARY OF 6600 VOLT CONNECTED LOAD

	Kva.
No. 1 Scalebreaker 2 x 300 h.p. x .746 @ 80 per cent power factor	560
No. 1 Rougher 2500 h.p. x .746 @ 76 per cent power factor	2450
No. 2, No. 3, and No. 4 Roughers 3 x 2500 h.p. x .746 @ 88 per cent power factor	6350
Finishing Train M. G. Sets 2 x 10,000 h.p. x .746 @ 100 per cent power factor	14920
Ward-Leonard M. G. Set	1250
Spray Pump Drive 800 h.p. x .746 @ 96 per cent power factor	620
Power and Light Transformers	6530
Total 6600 Volt Connected Load	32680

SUMMARY OF ROTATING ELECTRICAL MACHINERY

	Number	Total HP
Hot Mill Motors	348	30,452
Hot Mill Generators	15	23,225
HOT MILL TOTAL	363	53,677
Finishing and Shipping Motors	15	830
Finishing and Shipping Generators	2	400
FINISHING AND SHIPPING TOTAL	17	1,230
GRAND TOTAL	380	54,907



A special motor-generator set, composed of a 1250 h.p. motor, five 250 kw. generators and a 15 kw. exciter, supplies power to runout tables and coilers.

trimmer, roller leveller and shear, and will handle coils up to 50″ outside diameter.

One plate finishing unit for levelling, shearing and trimming cut lengths, consisting of a leveller, up-cut shear, side trimmer and a second leveller. This unit is served by a plate transfer extending over into the adjcent building, convenient to the piler on the end of the hot mill runout table.

One scrubbing, drying and oiling unit, consisting of a skew feed table, caustic spray tank, scrubber, dryer and sheet oiling machine, for handling cut lengths of 4 to 20 feet.

POWER AND WATER SUPPLY

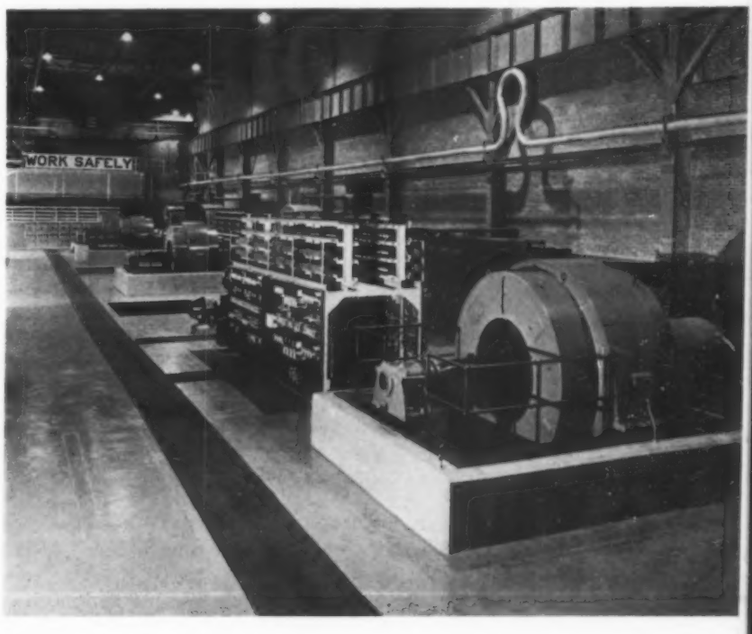
All electric power for the entire Indiana Harbor plant is generated on two power stations within the plant. No outside power connection is maintained. One station consists of one 10,000 Kva. turbo-generator and two 5000 kva. turbo-generators, both of 2300 volts, 25 cycles. Steam for these units is generated in stoker-fired boilers, using coke breeze and coal for fuel. The second power station employs blast furnace gas as fuel, with powdered coal as a standby. Prior to the installation of the 44″ hot strip mill, generating equipment in this station included five 10,000 kva., 2300 volt, 25 cycle turbo-generators. To meet the load requirements of the new expansion, a new 25,000 kva., 6600 volt, 3 phase, 25 cycle, 1500 r.p.m. turbo-generator was installed in the latter plant, which also includes six turbo-blowers for blast supply to the blast furnaces.

Switchgear for the new generating units is metal-clad factory assembled, with low oil content breakers located in steel cubicles equipped with safety interlocking between breakers, disconnecting switches and access doors.

Thus the total generating capacity of the power plants is 95,000 k.w. supplying a total plant load which varies widely with plant operations. At approximately 80 per cent operation, power loads average about 60,000 kw. with peaks up to 80,000 k.w.

A pump house has been built just south of the 44″ mill, where there are located three service water pumps and one hydraulic water pump. Space has been provided for doubling the present pump installation. The service water pumps are each rated at 20,000 g.p.m., 42 lb. pressure, and are driven by an 800 h.p., 730 r.p.m., 2200 volt motor. Water is taken through an intake flume from Lake Michigan, and is fairly free from sand and foreign material. At present there are installed three ⅛″ mesh chain belt traveling screens, each 7′–6″ x 24′–0″ in size, with 13′–6″ submergence. The screens are rotated by motor drives, and are hydraulically cleaned by 125 lb. pressure water sprays. After passing through the screens, the water is delivered directly to the pump suction well.

General view of motor-room, showing four synchronous motors driving roughing stands. Control panels are all factory assembled.



Modern COKE OVEN DESIGN *and* PRACTICE

By FRED DENIG, Vice President
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▲ THE purpose of this paper is to set forth some of the factors that should be considered in the design, construction, and subsequent operation of a coke-oven plant. It is intended to summarize some of the principal items that should be considered by any concern interested in the construction of coke ovens. Naturally, volumes could be written on the subject but this paper must be limited to certain essential considerations and will discuss only:

1. Preliminary Factors to be Considered Before Beginning Design.
2. What Destroys Coke Ovens.
3. What is Desired in a Modern Coke Oven.
4. Classification and Discussion of Oven Heating Systems.
5. Present Trends in Coke-Oven Design.
6. Self-Sealing Doors and Improvements in Machinery.

PRELIMINARY FACTORS TO BE CONSIDERED BEFORE BEGINNING DESIGN

A. The first consideration is the application to be made of the coke produced so that it shall have properties suitable for its desired uses. For example, shall the plant be employed to produce blast-furnace, domestic, or foundry coke? The kind of coke to be made determines to a great extent the kind of coal or coals to be used, their mixtures, etc. Consideration must also be given to whether the plant shall produce several varieties of coke and to whether this will necessitate the use of various coals or coal mixtures.

B. *Coals.* It is strongly advised that prior to considering the construction of a new plant the coals be thoroughly investigated, unless the coals proposed to be used are well known as to their general and coking properties. In investigating a new or unknown coal, the following should be considered:

a. Analysis.
b. Is blending necessary in order to produce the desired coke or to modify some coking characteristics?
c. Is the coal or coal mixture contracting or expanding? Considerable damage has been done in many plants abroad and also in some in this country through the use of expanding coals, and every plant should include a small test oven for the determination of expanding characteristics of coal and coal mixture.
d. Ash fushion and ash composition. For domestic use a high fushion-point of ash is required, and for various metallurgical uses it is necessary to know in advance the composition of the ash and its effect in subsequent process work. There are known instances where the ash has attacked the oven walls. A recent case is discussed by Rueckel in a paper before the American Ceramic Society.
e. Washing. Is it necessary to wash the coal to reduce the ash and sulphur content?
f. Moisture. Is the moisture normal or excessive?
g. Pulverization.
h. Weight per cubic foot of coal. This factor depends upon the moisture and pulverization and is necessary to know in order to determine the size of the coke plant.
i. The vertical shrinkage of the coal mass. This should be determined by large-scale experiments in order to properly locate the upper terminal-point of the heating flues.

All of these characteristics should be considered by both owner and builder so as to make certain that the ovens will not be damaged by some peculiar property of the coal. Also, sufficient tests should be made, both in small scale and large scale, to assure that the result-

Mr. Fred Denig presenting his paper before the A. I. & S. E. thirty-fourth annual convention at Cleveland, Ohio, September 27, 28, 29 and 30.

ant coke will have the desired properties or, if it does not possess such properties, that at least its characteristics are sufficiently understood to provide for appropriate utilization.

C. *Close consideration should be given to the by-product yields.* It is well known that the principal yields of by-products from the coking of coal are gas, ammonia, tar, light oils, cyanogen, sulphur, etc. In certain localities it may be more desirable to increase the gas yield at the expense of the tar and light oil. This can be done by locating the upper terminal-points of the heating flues at a higher elevation with respect to the coal line than would be the case with the same coal and the same oven in a plant desiring, for example, a high yield of tar and light oil. In general, if the terminal-points of heating flues are located high relative to the coal line, there results a tendency towards greater gas yields, more cyanogen, and, incidentally, more roof carbon than obtains when they are located lower with respect to the coal line. Consideration should also be given to the temperature at pushing. Coke is normally pushed at an average temperature within the range of 1750 degrees to 2200 degrees F. The use of higher heats to obtain higher temperature coke tends to decrease the liquid by-product yield and, in many instances, this use of higher heats tends to give a greater yield of coke calculated as the amount that passes over a 2-inch screen. This is, however, more true of the coke made from certain coals than it is of coke derived from other coals.

D. *Consideration must be given both to the size of plant and fluctuations in production.* For example, some plants when built have in prospect running at a uniform rate throughout their operative life. If such plant is large, the ovens can be built in blocks of 60 or 70 each. If there is prospect of the contemplated plant being operated at slow rates, consideration should be given to dividing it into smaller blocks so that in times of depression some of the blocks can be pushed empty while others are operating at a uniform load. This is an important consideration. Many plants find that a significant increase of the coking time changes the quality of coke and thus disturbs the coke practice in whatever process the coke is being used for, and in addition deranges by-product operation. For example, it has been found in the Pittsburgh area that when coke ovens are slowed down to a 30-36 hour coking time the resultant light oil is high in paraffines difficult to separate from the light oil. Plants encountering such situations would probably be better off to push some of the blocks empty and keep them warm by using a small amount of gas in the flues, and to push coke at normal speed on the remaining batteries. Some plants have already followed this practice with benefit.

E. *Labor Conditions.* The present-day trend is toward the elimination of all arduous labor, and today a coke-oven plant can be designed to eliminate practically all of the heavy labor formerly involved in its operation. For example, the present use on coke ovens of self-sealing doors now eliminates the antiquated and arduous job of door-luting and has reduced to a minimum the necessity for a man working for any period of time against a hot oven in hot weather. The result has not been altogether one of elimination of jobs, but has rather been primarily an elimination of tasks that are physically exhausting. It has been an object of designers to make working conditions around the battery as pleasant as possible, and the exclusion of taxing physical labor, smoke, etc., can now be said to be completely a reality. The use of double collecting mains or of smokeless charging cars has obviated that smoke and flame on top of the battery which in the past have made uncomfortable working conditions there. Today with the new designs, working conditions on the battery-top are as good as at any other point around the battery where men are employed. Improvements in painting and lighting have made inspection and maintenance in the alleys and throughout the battery much better than in the past. Ovens having certain designs of course lend themselves more readily than do others to ease of inspection of the interior of the ovens and of the brickwork, and for leakage, etc. Some ovens are much more easily repaired in case of leakage and, of course, the best design does preclude the necessity for all internal repairs and keeps those required on the exterior to a minimum. The best modern design is directed toward the reduction or complete elimination of such strenuous work in oven-heating as patching, replacement of gas nozzles, adjustment of sliding brick, etc. In other words, the trend is entirely toward a simplicity that renders practically unnecessary tedious adjustments in a block of ovens. It is not claimed that workmen employed as "heaters" can be dispensed with,

but it is claimed that the supervision of oven-heats has been reduced to a minimum.

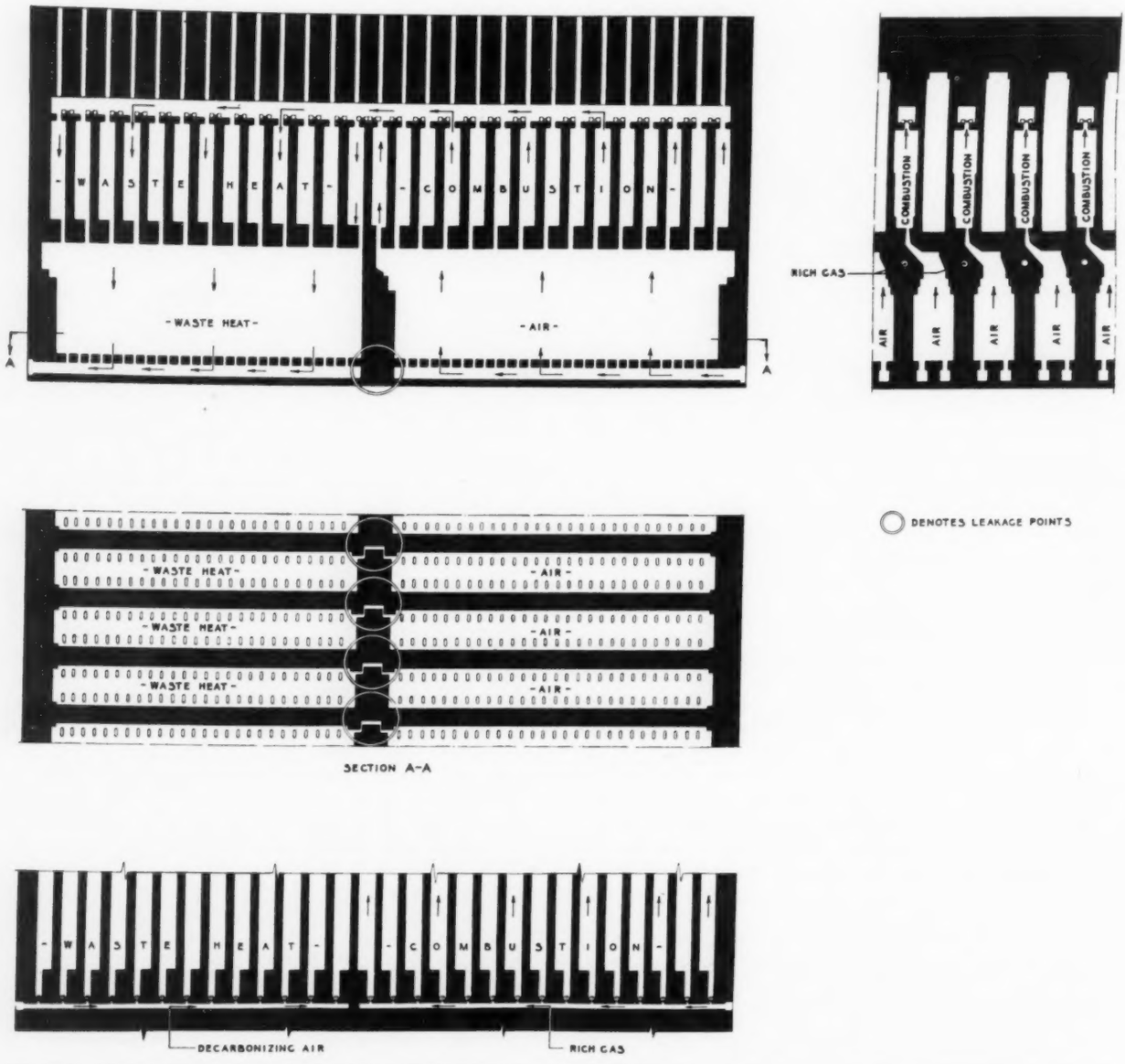
Naturally, in mechanizing the equipment around the battery, the required mechanical attention has probably been increased to some extent but, on the other hand, from the viewpoint of practicality this increase is compensated for by employing good design for the machinery and the use of first-class materials in its construction, and the mechanical attention has been reduced to little significance. Lubrication of equipment, etc., has been so arranged for that all coke-plant machinery can be lubricated with the greatest of ease and wherever practical such equipment has been so constructed that it can be lubricated entirely from some central point.

FIGURE 1—Koppers oven of the old type, designed for rich gas heating.

WHAT DESTROYS COKE OVENS

In considering the design of a coke oven, as well as its operation, it is always well to bear in mind the factors which tend to shorten oven life. In American practice, the life of coke-ovens has on the whole been very good. Probably the outstanding oven in this respect has been the old small-capacity Koppers oven. Experience has indicated that the typical old Koppers oven, if properly taken care of, has a life of twenty years or more, and such has been the enviable history of over 80 per cent of the old Koppers ovens built.

In discussing the life of an oven, it is always assumed that the builder installs the best silica brick, which for the past thirty years has been the most satisfactory material found for the construction of ovens. Naturally, if poor material is used, one cannot expect a good length-of-life from an oven, but it can be fairly said that coke-oven builders put in the best material they know of and, furthermore, that they use every reason-



able effort to test the material that is placed in the battery. Granting to the builder credit for installing the best material possible, the following factors can be said to be the principal causes of coke-oven destruction:

A. *The use of expanding coals.* Probably more ovens have been damaged by the use of dangerously expanding coals than for any other reason. The use of an expanding coal is in effect very much like the use of a dangerous drug. It is charged into an oven and its results are unseen until the damage is found. There are now available excellent methods for testing the expanding characteristics of coals, and today there is no excuse for any coke plant being without suitable equipment for determining this characteristic. Furthermore, any plant that charges to the ovens mixtures consisting partly of expanding coals should test the mixed coals in a systematic and routine manner so as to prove beyond doubt that the mixtures are safe. This subject has been discussed for years in other articles, and the writer has referred to a few of them at the end of the paper.

B. *Careless heating.* Careless attention to the oven-heats and also the use of excessive heats endangers the battery by fluxing. In the early history of the coke-oven art, some ovens were lost as a result of fluxing caused by carrying temperatures beyond those that the brickwork would endure. Today this matter is well controlled in most plants by routine temperature readings, etc.

C. *Irregular heating.* Irregular heating caused by poor design and maladjustment of the heating system of the batteries will cause local high temperatures and spotty coke, portions of coal to remain uncoked, and abnormal pushing stresses. Such conditions are also liable to cause excessive formation of roof or wall carbon, and they all tend to increase the resistance to pushing and thus lead to those strains in the walls that subsequently cause damage and deterioration of the battery.

D. *Bad design.* Some designs of ovens leave weak points, in the brick structure, which will eventually occasion trouble. This will be discussed more in detail later in the paper, but the following points can be presently listed as instances:

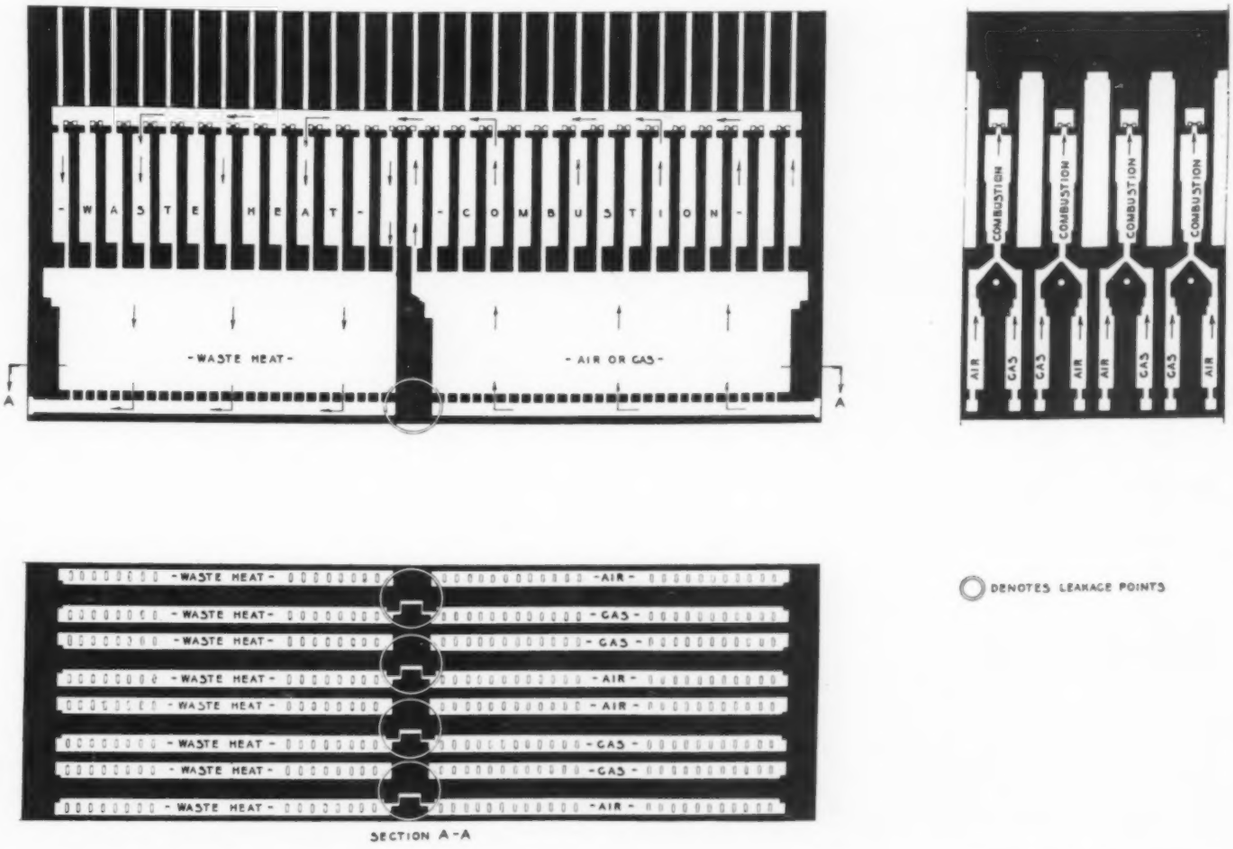
a. Improper taper to the oven which increases the amount of force required for pushing.

b. Designs involving the conventional horizontal flues located near the coal level, which has always been recognized as the weakest spot of the ovens.

c. Improper location of expansion joints and also the failure to provide for expansion joints. Improperly placed expansion joints are liable to be sources of leakage.

d. Counterflow of waste gas and of the rich or lean fuel gases. This is coupled with those designs that permit excessively high pressure differentials in the ovens, and, wherever this situation occurs,

FIGURE 2—Koppers oven of the old type, designed for producer gas heating.



either high or low Btu. heating gas can leak directly into the waste gas, and since the waste gas carries an excess of air such leakage usually does cause fluxing in the oven-heating system and may injure not only the foundations but even the piling. There can also be leakage of gas from the oven into the combustion system thereby causing local combustion and perhaps fluxing of the brickwork.

e. In some instances there is found at the ends of the ovens a brick deterioration that results from an excessive cooling of the end-flues, which in itself might be caused by several circumstances. For example, cooling down a battery so as to operate on slow coking time and in order to bank it with no pushing. Naturally, radiation cools the ends, and if care is not taken to keep them at a temperature above the contraction point of silica a contraction of the brick will take place, cracks will form, and thus ruination begins unless promptly attended to. Sometimes careless maintenance methods permit leakage through the regenerator faces, which in turn cools the ends of the regenerators, causing dark end flues that result in the formation of cracks in their flue brick, etc.

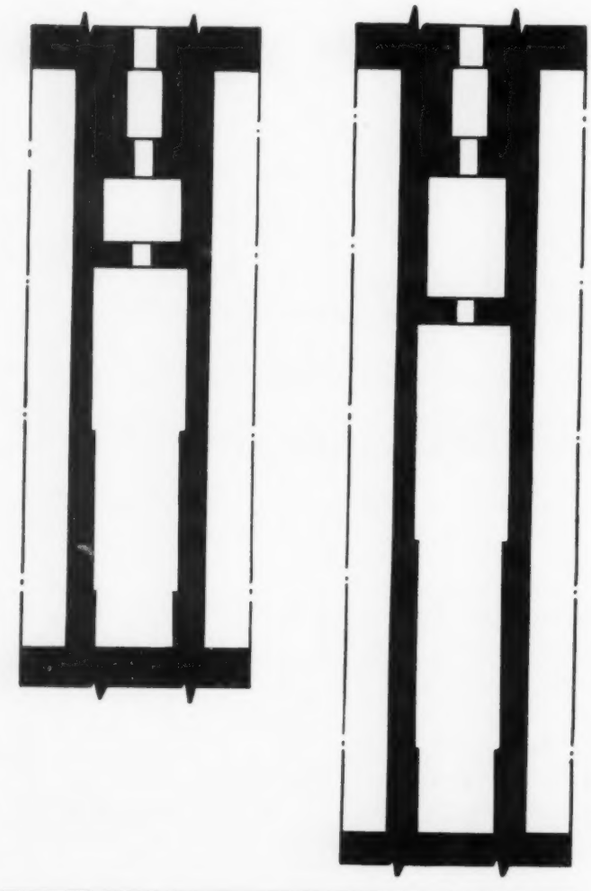
f. There are known instances where door fires are allowed to burn and overheat the buckstays. A sudden rainstorm will cool the top tie rods and exert a pull on the buckstays causing them to bow. This circumstances allows the jamb castings to work out of position and more especially on the coke side, thus permitting the end flue liners to loosen; carbon deposits can then build up behind the jamb castings and force the buckstay further outward so that this difficulty will become aggravated as times goes on.

E. *Improper pressure conditions.* Another cause of oven deterioration is the failure in operation to properly balance the pressures in the ovens with respect to those both of the atmosphere and the combustion system. The coke oven is not a hermetically-sealed cell. During its erection every attempt is made to secure tight joints and also to use joints of the smallest size consistent with good construction, but brickwork is always porous and if cracks develop, for one reason or another, more or less leakage will result, depending on the condition of the oven brickwork and the pressures within the structure.

Operators depend largely on the formation of a skin of carbon on the oven walls and in the pores of the bricks and joints to keep the ovens tight. This is some times difficult to maintain, and consequently the best operation is that practice which tends to maintain the ovens at such condition that, at the end of the coking time, there exists a slight plus-minus pressure of gas in the bottom of the ovens. This will prevent the infiltration of air into the oven chamber at its ends. Best operation provides for a slight suction, say minus 2 mm. water gauge, or thereabouts, at the top of the upflow air regenerators to prevent leakage of air from the regenerators into the oven chambers. Cases are known where the upflowing regenerator pressure has been such as to force air into the bottom of the ovens, with subsequent slagging of the oven floors and walls. Good design and good operation demand that there shall be the minimum drop of pressure in the oven system so as to minimize the leakage of oven gas and by-products into the combustion system. Good design will not permit adjacent flow of waste gas and fuel gas, but rather interpose a layer of air therebetween to prevent cross leakage.

FIGURE 3—Old Koppers oven with oven chamber 9′ 10″ high, for coke-oven gas firing.

FIGURE 4—(right) Koppers oven, 13′ 0″ high, for blast furnace gas heating.



WHAT IS DESIRED IN A MODERN OVEN

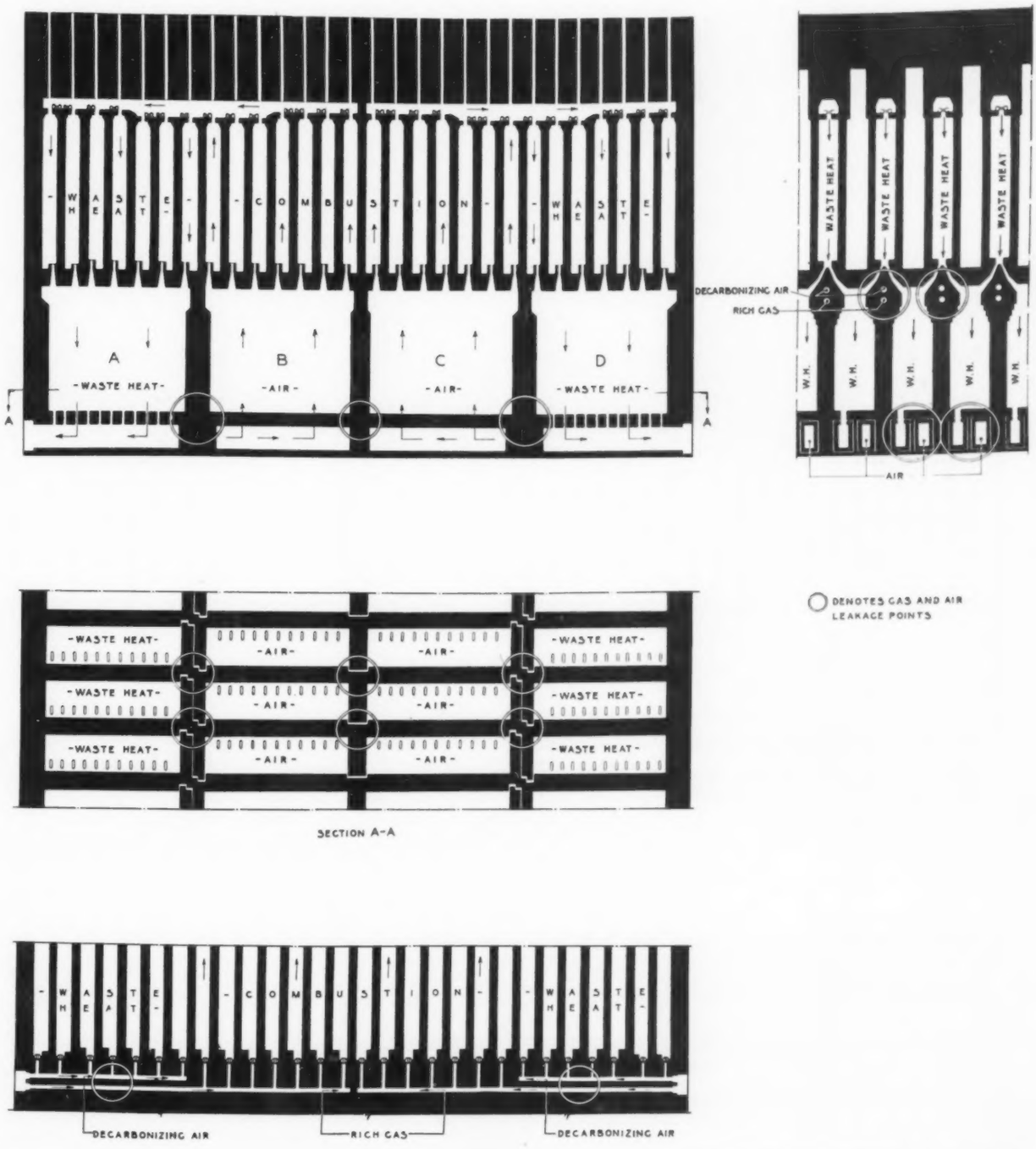
Consideration of the above points leads to the question of what is desired in a modern oven. Briefly, the characteristics desired of the modern oven may be listed as follows:

A. First, and foremost, the delivery of a uniformly-heated coke: By "uniformly-heated" is meant a coke-cake that is uniformly heated from end to end and from top to bottom, with a slight tapering off in temperature toward its top and with this further provision—that consideration has

been given to the kind of top that is desired while bearing in mind the previous discussion of its effect on the type of by-product yields.

B. The securing of as low a heat requirement for underfiring as is consistent with the temperature of the coke pushed and type of by-products preferred. In an oven having a terminal point of heating flue low with respect to the coal line, there will be produced a coke with cool tops. Many operators attempt to raise the temperature of such tops and thus overheat the bottoms, and in so doing consume an additional amount of heat, which in some cases is equal to an excess of 10 per cent or more over what would be normal practice. This condition can be obviated by closer consideration to the vertical shrinking quality of the resultant coke and to the proper location of the upper terminus of the heating flue. Another factor affecting the heating of the upper part of the coal charge, in addition to the location

FIGURE 5—Koppers double divided oven designed for rich gas heating.

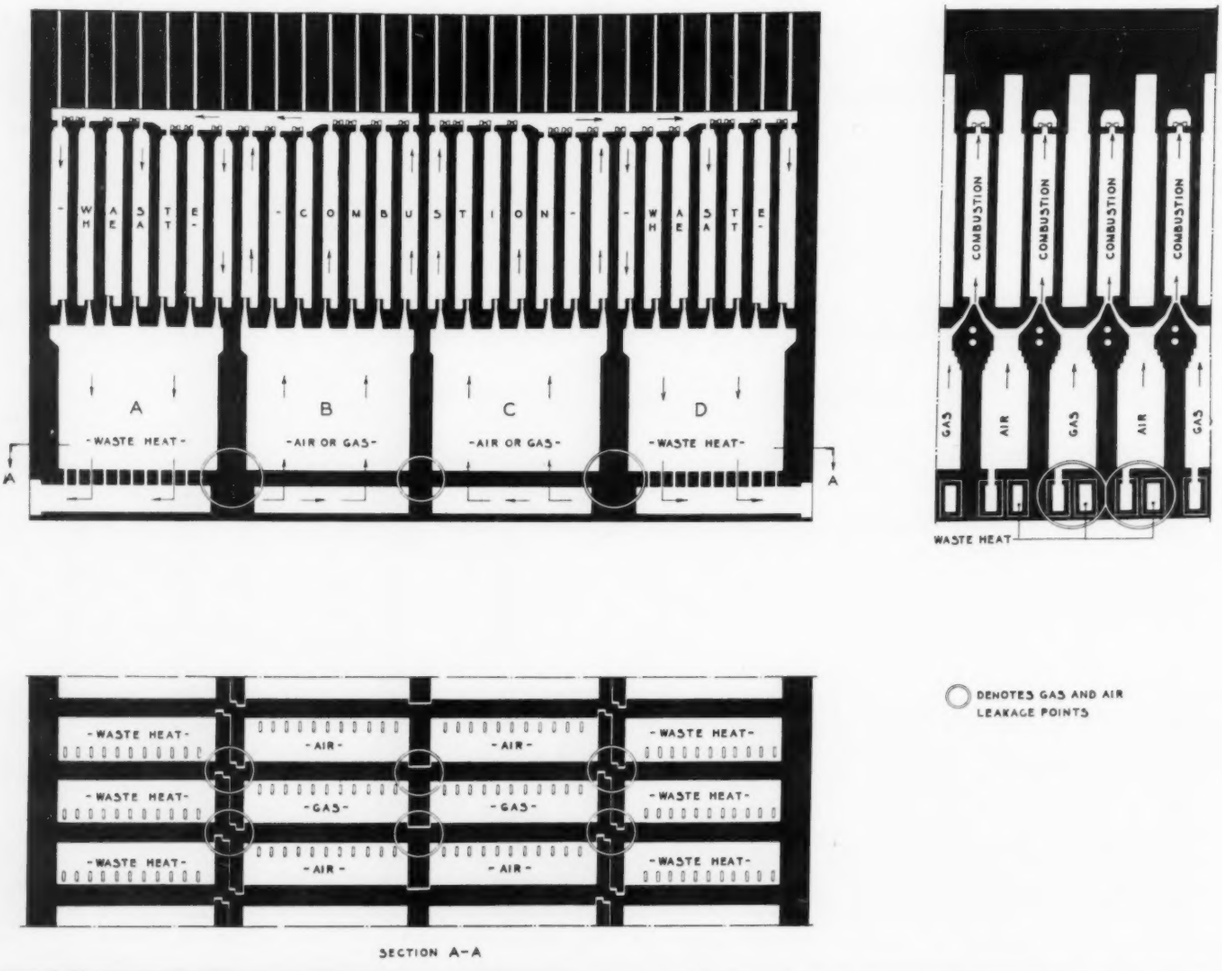


of the terminal point of the heating flues, is the size of the horizontal flue in those heating systems where horizontal flues are used. Large horizontal flues interfere with the uniform heating of that part of the coal lying opposite the horizontal flue because of the fact, as has been shown by many writers, that the bulk of the heat is transmitted to the heating wall by radiation from the flame and because by the time the burning gases reach the horizontal flue, combustion is complete and the temperatures of the gases are dropping since much of their radiant heat has already been given up to the walls of the vertical flues, the heating of the coal in the region of the horizontal flue itself must depend almost entirely upon the sensible heat transferred from said gases to the walls. Usually, the horizontal-flue walls are thicker in construction than the regular vertical flue liners of the oven wall, and thus the combination of extra thickness of wall, inability to secure radiant heat from the burning flame, and the dependence upon the sensible heat transferred from the gas to its walls, makes the heating of the section adjacent to the horizontal flue a difficult procedure. This is well demonstrated in practice where the so-called "black tops" are pushed. It is obvious that this defect can only be corrected by the virtual elimination of flues for horizontal flow above the vertical heating flues.

The problem of securing maximum yield of by-products and coke uniformly heated in a vertical direction and a low heat requirement for underfiring must be considered in the light of the axiom that the operator cannot eat his cake and still have it. The attempt to take a low terminal point of heating flue oven and overheat it will result in high consumption of heat for underfiring. The pushing of coke at high temperatures will result in greater heat consumption. The question of whether a battery must burn both oven gas and a lean gas such as producer gas or blast-furnace gas should also be borne in mind. Combustion of lean gas results in a long flame while combustion of coke-oven gas produces a short flame. A properly-designed oven will automztically compensate for this difference and produce a uniformly-heated charge irrespective of the kind of gas used.

Fair discussion of the coal problem with the de-

FIGURE 6—Koppers double divided oven designed for blast furnace gas heating.



signer and builder by the operator will result in proper location of the terminal point of heating flue, which in turn will give a satisfactory by-product yield and reasonable heat requirements for underfiring. Heat for underfiring can also be reduced by the use of better types of checkerbrick improved distribution of gases in the regenerators, the application of a design for preventing by-passing of lean gas or air between their regenerators, and the judicious use of insulating material throughout the battery.

C. The desired oven will have a minimum loss of by-products by leakage into the heating system, or vice versa, will prevent the leakage of combustion products into the oven chamber where they cause partial combustion of by-products, formation of nitric oxide and gum-forming compounds.

D. The operation of the oven is made easy by:

a. Mechanical handling of all equipment, automatic door extractors, self-sealing doors, smokeless charging, etc.

b. A design that requires minimum labor and supervision on the part of the heating staff and should be of a type which permits inspection of every part of oven and regenerators, and patching, etc., to be performed with the minimum of labor.

c. Design that requires a minimum of oven and of oven-machinery maintenance.

E. The most desirable type of oven, as can be seen from the previous discussion, is the low-differential oven. By "low differential" is meant an oven that will have the minimum pressure drop throughout its combustion system. This provides for minimum leakage from the oven chamber into the combustion system and also of air thereinto whether it be from the atmosphere or from air regenerators.

F. The best design will eliminate counterflow between waste gases and fuel gases. This will be done by the judicious location of the fuel supply ducts or lean gas regenerators with respect to the waste gas regenerators. Wherever possible, there will be an air regenerator or air-layer located between the waste gas and the fuel gas ducts or fuel

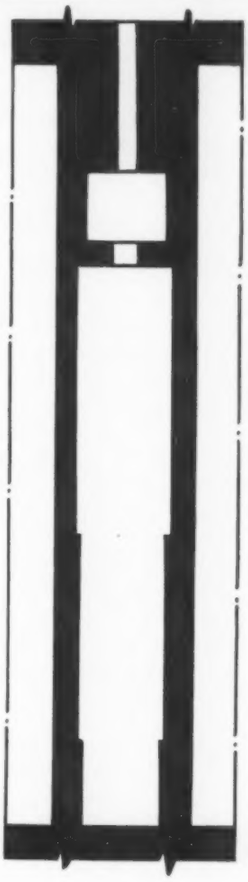
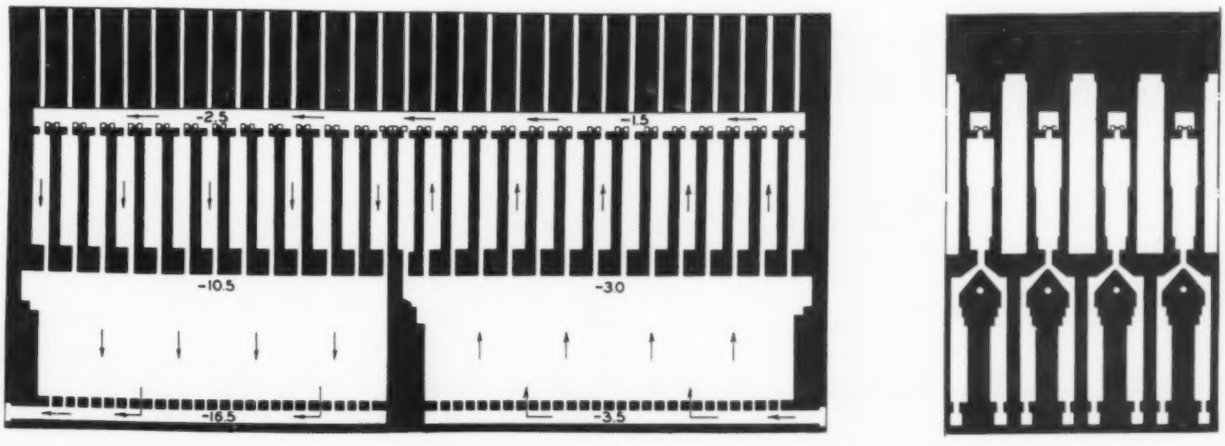


FIGURE 7—Double divided combination oven for blast furnace gas firing.

FIGURE 8—Pressure survey, in millimeters water column, in old Koppers oven burning producer gas, with 19 tons of coal per day throughout.



gas regenerators in order to properly isolate the fuel gas from the waste gases.

G. The brick structure should be designed stable and strong so that there will be no weak points to crush or shear, no weak areas in the walls which will push in on the exertion of strain, no sections that are impossible to repair, and no expansion joints detrimentally located; bearing in addition in mind that no oven can be designed at an economic cost to resist the forces of expanding coals.

H. In case of shut-downs of ovens, the oven that is free from complicated counterflow passages, is accessible in all its parts and has the lowest differential will, when again brought to operating temperatures, show the least effect of a shut-down.

I. In this day and age, a coke-oven plant should be so built that it can be heated with both coke-oven gas and with blast-furnace gas. In the blast-furnace and steel industries, large quantities of low heating-value blast-furnace gas are produced the most of which is not adaptable for high-temperature operation within the steel plant and therefore of which the greater part is burned under boilers. It is today well recognized that the ideal outlet for blast-furnace gas is the heating of coke ovens which makes possible the release of all of the high Btu. coke-oven gas for steel-plant purposes. The excess blast-furnace gas still available can be mixed with coke-oven gas and the mixture thus produced is adequately high in heating value as to meet the requirements of all steel-plant operations. In other words, a coke plant that can be heated with blast-furnace gas can exchange with the steel plant Btu. for Btu. in high value coke-oven gas and thus solve most of the heating problems in the steel plant. Coke ovens because of their highly efficient regenerative system are the perfect combustion unit for the use of blast-furnace gas, which is proven by the fact that in spite of its low heating value and large amounts of inerts the coking of coal does not require any more Btu.'s when using blast-furnace gas than when using coke-oven gas.

CLASSIFICATION AND DISCUSSION OF VARIOUS OVEN SYSTEMS

There have now been analyzed factors preliminary to the consideration of oven design, factors dealing with the destruction of coke ovens, and a summation of what is desired in the modern oven. This then leads logically to the question of what kind of oven should be considered. The following types of ovens have been built in the past:

A. Beehive ovens.
B. Waste heat ovens.
C. Recuperative coke ovens.
D. Regenerative coke ovens.

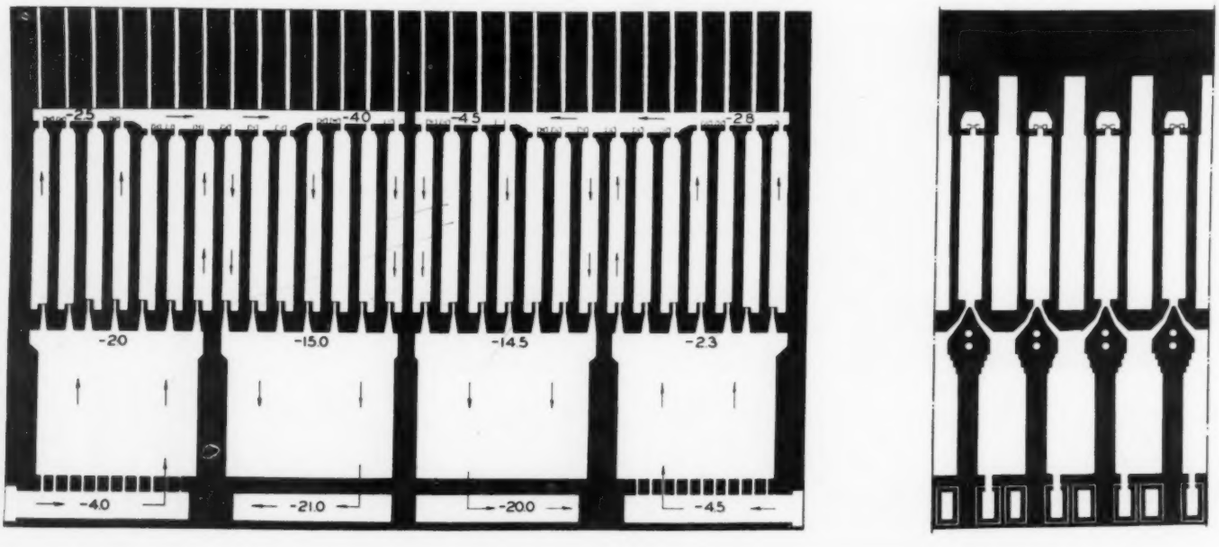
It is now universal practice, largely for the sake of heat economy and a maximum surplus gas yield, to build regenerative ovens. These may be divided into the following classifications:

a. Ovens with horizontal heating flues; and
b. Ovens with vertical heating flues.

The oven with horizontal heating flues has been abandoned by all builders because of their great expense of construction, the poor heating obtained in the longer horizontal flues, and because of the extreme differentials of pressure therein.

The vertical-flue ovens have remained and are standard today with all builders because they are cheaper to erect and provide for better heating conditions. The vertical-flue system may be divided into the high-differential type of oven and the low-differential type of oven. Under the high-differential type of oven may be classified the old and familiar Koppers oven, and that modification of it built in the past by Koppers

FIGURE 9—Pressure survey, in millimeters of water column, in double-divided oven burning blast furnace gas, with 21 tons coal per day throughput.



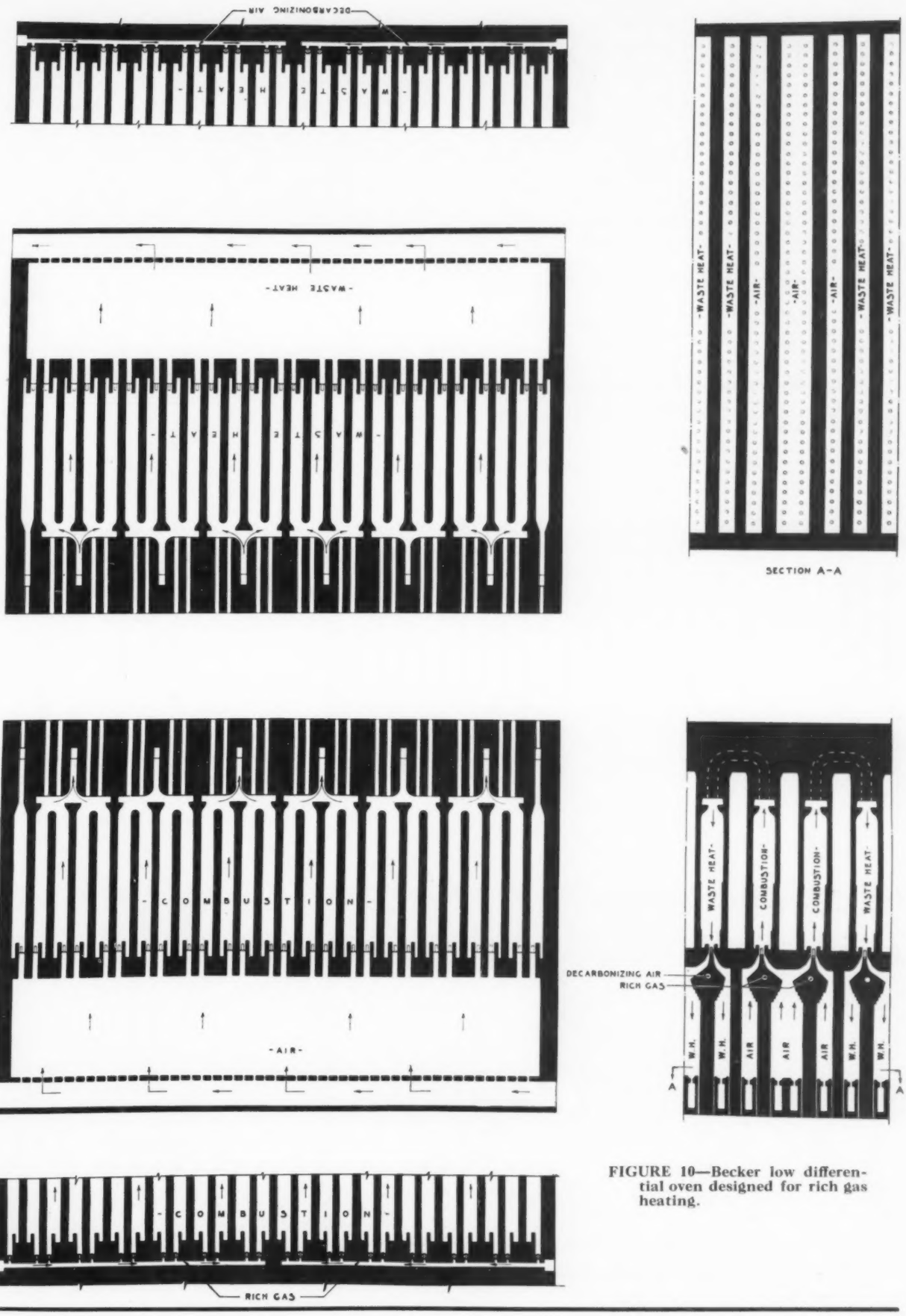
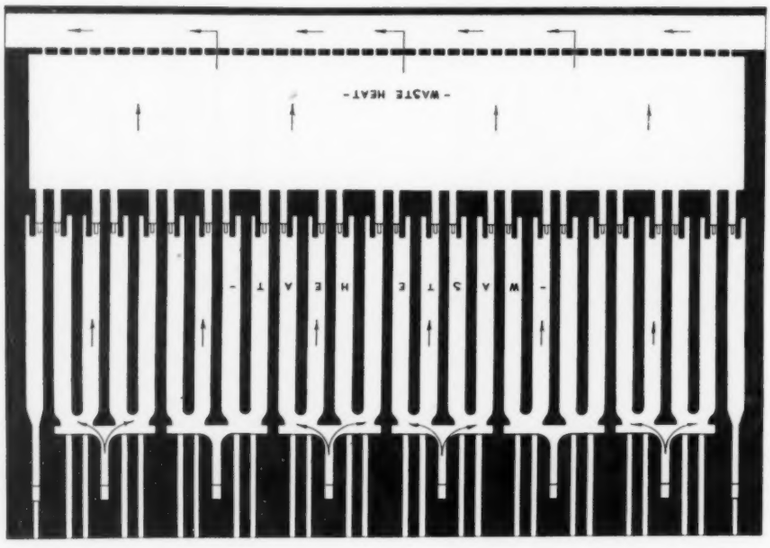


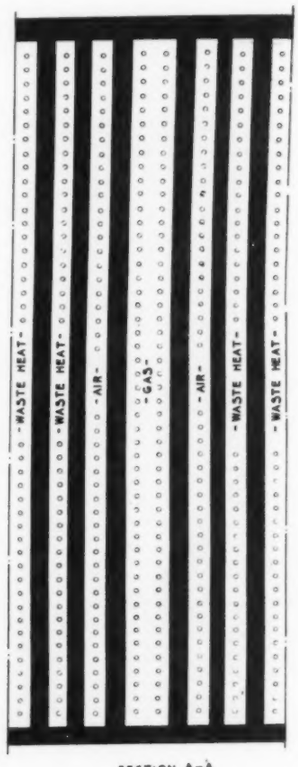
FIGURE 10—Becker low differential oven designed for rich gas heating.

which is in reality nothing more than the old Koppers ovens built back-to-back and known as the Koppers "double-divided" oven. The old small-capacity Koppers oven has been operated in the United States for thirty years and gives good results when heated with either coke-oven gas or producer gas. However, past demands were to reduce costs and to increase oven capacities. The usually built Koppers oven of the older type was not more than 37 ft. long, having a coal line 8-9 ft. high, and an average cubical content of 450-500 cu. ft. An oven with a larger capacity was later desired and one that was adapted for heating with blast-furnace gas. These old Koppers ovens were reasonably satisfactorily heated by coke-oven gas.

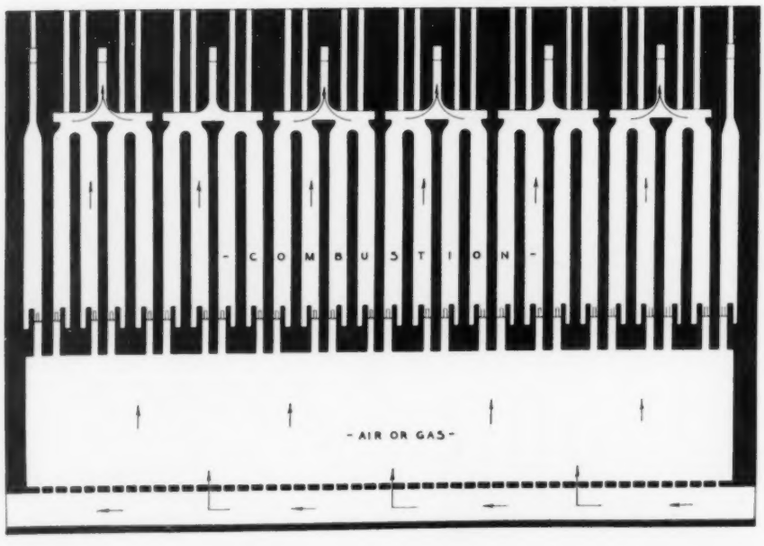
Because of the demand for a larger capacity oven and in order to handle lean gas, such as producer gas or blast-furnace gas, it was necessary to considerably enlarge the conventional horizontal flue located near the coal level in order to prevent excessive flow velocities, and this resulted in a weakening of the upper structure. Also, in order to control the volume of fuel gases entering the individual flues, it was necessary to use sliding bricks where the vertical flues entered the horizontal flue, and this in itself considerably increased

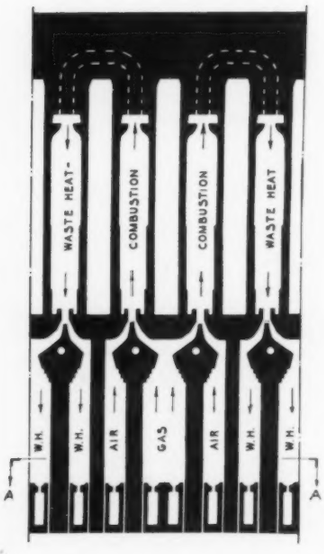
FIGURE 11—Becker low differential oven designed for blast furnace gas heating.





SECTION A-A





the pressure differential between the heating and horizontal flues and consequently the pressure differential throughout the battery. The horizontal flue for blast-furnace gas practice became so large as to render its use both impractical and dangerous to the life of the oven.

Figure 3 illustrates an old Koppers oven with an oven chamber 9 ft 10 in. high (8 ft. 10 in. coal line) designed for coke-oven gas firing.

Figure 4 illustrates a Koppers oven 13 ft. 0 in. high (12 ft. 0 in. coal line), and shows the horizontal flue necessary to handle the blast-furnace gas used for its heating.

In comparing an old Koppers oven having a capacity of 18 tons of coal per day, when using coke-oven gas as the underfiring medium, with a modern oven of 28 tons of coal per day throughput while using blast-furnace gas for underfiring, we find that the volume ratio between their waste gases is in the proportion of about 1:2¼. In order to maintain comparable velocities in the two horizontal flues, the horizontal flue of the larger oven would have to be not less than 2¼ times the area of the old Koppers horizontal flue. This entire space would be unsupported and so weaken the horizontal flue that it could be easily pushed in, and such design was therefore out of the question. Experience had already taught that a horizontal flue of say 13-inch height, even in small ovens, was altogether too weak. Experience has also proven that this is even much more serious for the higher ovens because any given angular distortion is reflected in the horizontal flue in proportion to the oven height.

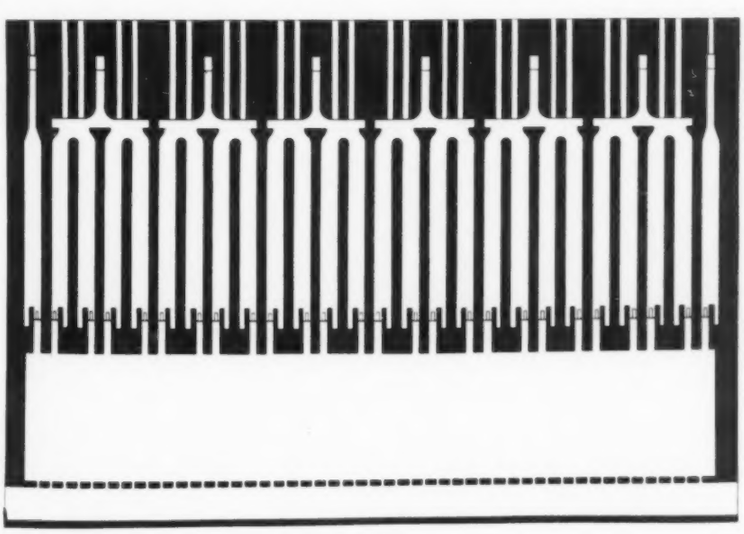
Another serious defect of such a large horizontal flue is that it materially retards the coking of the coal mass lying adjacent it and as much as one or two hours in respect of the balance of the coal. This causes high heat consumption for the underfiring and a non-uniformly coked charge and reduction in plant throughput.

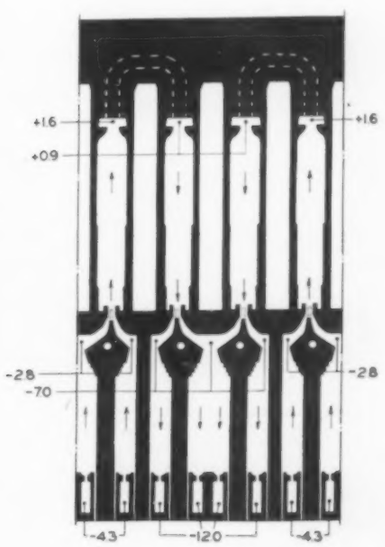
Designers throughout the world then sought various means of overcoming this difficulty. Even as late as 1937 the question has arisen—What could be better than to place two short Two Divided Koppers ovens end to end and so reduce the size and length of the horizontal flue? However, as long ago as 1921 American Koppers tried this design in a small plant and Koppers Germany for a time adopted a construction (the double-divided oven, some times called the four-divided oven) wherein instead of having only two regenerators per oven, that is, a coke-side and pusher-side regenerator, and of burning from the coke side and pusher side, the oven was divided into four heating sections (as is evidenced in Figures 5 and 6), or actually into what was equivalent to two short Koppers ovens end to end. In this design gas could burn, for example, simultaneously in sections A and D and waste gases flow downwardly into B and C, and thence to the stack canal. Another combination would be to burn in A and C simultaneously as the waste gases pass to B and D. In either system, of course, reversals would take place. This design reduced to some extent the horizontal-flue cross-sectional area for ovens of modern size but it still retained the structural weakness and other drawbacks previously cited.

Figure 7 indicates the area of the horizontal flue for a double-divided oven that is 13 ft. 0 in. high and uses blast-furnace gas as the heating medium. Some designers might be tempted to further reduce the horizontal flue area, but this would increase the pressure drop from the vertical flues to and through the horizontal flue for a combination of reasons.

As a gas volume flows along the horizontal flue there is added thereto other volumes of waste gas being discharged into the common horizontal flue from still other heating flues, and in order to maintain the required rate of flow there must be an increasing pressure drop from the far end of said horizontal flue, where there is a minimum flow to its discharging end at which point there is a maximum volume of waste gas. In a Koppers oven this would be the total discharged from

FIGURE 12—Pressure survey, in millimeters water column, in Becker low differential oven burning blast furnace gas, with 24 tons of coal per day throughput.





fourteen flues, or in the case of the double-divided oven this maximum volume would be the total for seven flues. The more heating flues that a horizontal flue serves, for any given size, the greater must be the pressure drop throughout that flue according to the Bernoulli theory for gas flow.

In order then to control the volume discharged by each vertical flue into the common horizontal flue, it is necessary to cut down progressively in the direction of flow on the port area of discharge into the horizontal flue. This is done by means of the familiar sliding brick. These brick are pushed over the openings so as to give only enough opening to discharge the requisite amount of waste gas into the horizontal flue. This in itself involves a pressure drop in the restricted area set up by the sliding brick which is repeated on the downflow side through the restricted openings there, and the sum of the two drops through the up- and down-flowing vertical flue ports and the horizontal flue represents the largest part of the pressure drop through the combustion system.

In building the double-divided oven there would be seven flues discharging into a common horizontal flue. Should the horizontal flue remain the same size as the old Koppers horizontal flue, then the differentials would be less but the structural weakness would remain. If the area of the horizontal flue is cut in half there is some improvement in structural strength but the pressure differentials remain the same as with the old Koppers oven (assuming the oven to be of the same size as the old Koppers oven), but when the oven is enlarged to the present-day dimensions and especially when heating with blast-furnace gas, such differentials become exceedingly high and unsatisfactory for good and safe operation. See Figures 8 and 9. The diagrams represent actual readings of pressure conditions within the old Koppers oven using producer gas and within the Koppers double-divided oven using blast-furnace gas for heating the ovens. From these readings the differentials can easily be computed. When using coke-oven gas these differentials are, of course, smaller, but it must be remembered that the heating of the ovens with low Btu. fuel gases is under discussion and the diagrams demonstrate the high differentials set up by these two systems of heating mentioned.

The large pressure drop that is created between the up- and the down-flowing flues and the horizontal collecting flue is caused by two factors—first, as already mentioned, by the restricted area set apart by the regulable sliding-brick opening, and second, by the whirling and baffling effect of the hot gases as they strike the sliding brick and the brickwork supporting it as well as the opening it controls. Actual measurements show that a substantial amount of the pressure drop is due to the baffling effect of this brickwork. Therefore, the minimum pressure loss can be secured only by having vertical flues with tops practically entirely open.

In order to eliminate the effect of the restricted area of the sliding-brick openings, the designer might be tempted to eliminate the sliding brick entirely and to open-up the ports leading from vertical flues to the horizontal flue and to provide for all of the regulation at the bottom of the flues, i.e., at the air and gas ports. However, this will not give satisfactory regulation. If the flue bottom-port areas are proportioned according to the taper of the oven, then the upflow of air (or gas) or down-flow of waste gas will depend on the pressure differential between the top of the regenerator and the horizontal flue. The pressure changes progressively along the horizontal flue and as a result there will be unequal flows through the different vertical flues. If the air-port areas are changed to correct this condition, then this setting will be good only for one fixed coking time and only one kind of fuel gas. If either the coking time or the fuel gas is changed, then the setting becomes incorrect. Worse yet, the high differentials remain because in order to regulate the various flows restrictions must be made in port areas, and differentials of pressure result. It becomes therefore evident that regulation at the heating-flue bottoms and with minimum loss of pressure can only be successfully achieved with practically zero pressure drop along the horizontal flue, and this in turn really means elimination of variable flow velocities at the tops of the flues

Figures 5 and 6 show diagrammatically points of cross-leakage in the double-divided oven. Furthermore, when burning coke-oven gas in the interior flue-groups there is a counterflow of waste gas past the guns feeding fuel gas to said groups. For example, when burning in group B, the waste gas passes down group A and in so doing flows by the gun-brick feeding group B, which must pass just beneath the bottoms of the flues of group A. Furthermore, the off-gas gun is always under the suction of the downflow regenerator and there can easily be leakage between it and the gun carrying gas. This leakage of fuel gas is carried into the downflow regenerators and causes great damage. There is no known means of preventing this condition, when using the two-gun feed, except patching, and this is no cure-all. Some designers have attempted to circumvent this condition by the introduction of the underjet heating method. However, this scheme introduces counterflow between some of the upflowing fuel-gas risers, located in the regenerator wall, and the sole-flues beneath the downflowing regenerators. To overcome this condition as well as to take care of blast-furnace gas, the sole-flues beneath the regenerators were lined with stainless or ordinary steel, thus fully demonstrating the realization that the intermediate brickowrk would not prevent the leakage created by high differentials of pressure. There can be no good bond between brick and steel; the difference in expansion between brick and steel sets up movement that causes ultimate leakage. Such makeshifts will prove unsatisfactory because they fail to correct the inherent basic difficulty, i.e., high differentials of pressure.

The double-divided oven construction requires a division wall between A-B, B-C, and C-D. These regenerator division walls prevent inspection of the inner regenerators and, consequently, their condition can never be known until disaster has overtaken the oven.

In order to allow for expansion in the direction longitudinal of a battery, the division walls between A-B, B-C, and C-D must be provided with expansion joints. No matter which system of burning is used—for example, burning up A-D and down B-C, or burning up A-C and down B-D—there will always be division walls

that are subject to a differential pressure. These division walls must be equipped with expansion joints because the brickwork will expand on heating. It is exceedingly difficult—as all designers and operators know—to keep expansion joints tight and, since these joints are inaccessible and are under high differential pressure conditions, leakage through them will take place when using blast-furnace gas, the result being loss of gas and possible damage.

Thus we see that the double-divided oven has three serious faults namely:

A. High differentials of pressure;
B. Impossibility of ascertaining when leakage takes place within the inner regenerative sections; and
C. As a corollary of B, in the event leakage does take place, it is exceedingly difficult to repair or replace any damaged parts.

European builders have constructed a great number of double-divided ovens in England and on the Continent. Koppers Company tested its principle in one small American plant, and during its operation investigated the detrimental effects of the high-differential pressure conditions and refused to follow the European designers. As a result, the Becker oven was developed. The correctness of the judgment of the American Koppers Company was borne out by the fact that, because of the bad experience with the double-divided oven, prominent European designers and builders, such as Koppers Germany, Otto, Coppee, and Simon-Carves dropped the double-divided oven and substituted for it some type of low-differential oven, having designs, however, different from that of the Becker oven. European designers have now cast the double-divided oven into limbo, but some American designers are still using it with added complications in a vain effort to overcome its basic faults.

LOW-DIFFERENTIAL OVENS

There are two outstanding designs of low-differential ovens. The first is the familiar hair-pin type which has been built extensively throughout Europe and Asia, while the second type, the Becker oven, has been built throughout the world and is of course exceedingly well-known in America.

The hair-pin flued oven will effect low differentials of pressure and thus may be satisfactory in this respect. One of its difficulties of design is, however, the securing of proper regenerator arrangements. As explained before, it is always desirable to have a blanket of air or, in other words, a regenerator full of air, between the lean gas that is being preheated and the downflowing waste gas. The including of this feature in the hair-pin flued oven has given rise to difficulties in its regenerator design and construction. Only thin walls can be used between gas and air, and when the objective is finally reached, a situation results where, at such times as the oven is heated with coke-oven gas, the fuel-gas ducts are located between an upflowing air regenerator and a downflow waste-gas regenerator, and if there is any tendency for leaks, naturally, the fuel gas will short circuit into the downflow waste-gas regenerator. With the exception of these drawbacks, the hair-pin oven approaches more closely the better oven type.

The Becker oven is today the most nearly perfect type of combination oven that has been designed and built. A ready inspection of the flow diagram (Figure 10—Figure 11) will quickly demonstrate the simplicity of the combustion gas system. All of the flues in any burning wall burn simultaneously upward while all of the flues in the adjoining companion or twin wall are filled with waste gas flowing downwardly. The upflowing and downflowing flues are separated by an oven full of coal; the fuel gases, both high or low Btu., are blanketed on each side by air flowing in the same direction as is the fuel gas. In the Becker oven an upflowing and downflowing wall are connected by flues known as crossover flues. The whole combination of the upflowing and down-flowing flues and of the regenerators and crossovers may be easily conceived of as a book—the outside covers representing flues and regenerators, the back representing the crossover sections, and the leaves representing the coal. The whole combination can be laid out flat, as by opening the book, and the flow shown on a flat plane. Another interesting viewpoint of the Becker oven is that it can be likened to a hair-pin oven with the paired flues turned at right angles and having certain of such adjacent flue pairs grouped together with a layer of coal located between the individual flues of the pairs comprising a group. This arrangement of twin walls makes possible the ideal grouping of regenerators beneath them.

The regenerators and sole flues are open for inspection and accessible throughout from end to end. There can be no cross-leakage of fuel gas into the waste gas or the air, in the Becker oven, because of the simplicity of the flow system and the care taken to blanket the fuel gases with air and also because both lean gas and air are carried under identical pressure conditions. The method of control of combustion in the flues is simple. The air is regulated by one single port and plug in each flue. When heating with oven gas and the gun system of feeding fuel gas to the flues, the gas is controlled to each individually by means of sillimanite nozzles. Sillimanite nozzles do not swell or deteriorate as do clay nozzles. When operating with blast-furnace or producer gas, the simple port and plug arrangement cited above is fully adequate. Hand regulation and guesswork is eliminated. There is nothing to regulate. The various port areas can be easily computed, and in the event that a change in their cross-section is required, it can be quickly and easily accomplished by merely exchanging plugs. In those instances where the underjet underfiring system is used, the regulation of fuel gas is equally simple.

Figure 12 shows a pressure survey of a Becker burning blast-furnace gas.

Since the flow of gases through the crossover flue exerts no such influence on the discharge from the vertical flues, as does the common horizontal flue in the other designs, as before explained, this crossover flue can be of small dimensions. (See Figure 13—compare with Figutes 3, 4, and 7.) It is functionally and in effect absent from the heating flue system, and never interferes with gas flow in the heating system at any coking time or condition or variety of heating gas.

The old function of the horizontal flue to collect waste gases from one group of flues and to convey them

horizontally over into therewith connected vertical flues is eliminated. In the Becker oven this horizontal flue is structurally and functionally absent, the waste gases merely passing more vertically than horizontally through such space, which is no larger than is necessary to equalize pressure over a group of four flues.

Because the Becker oven needs no horizontal flue in the older sense but merely an equalizing space the strength of the oven wall is considerably increased over those ovens requiring horizontal flues for gas transfer. (See Figures 14 and 15—compare to old Koppers Figure 16.) There are no sliding brick in the Becker oven because they are not required since there is no pressure drop of the waste gas flowing before it reaches the crossover flue.

All oven designers have been working on improved regenerator design and attempting to secure the proper relationship between mass and surface. As a result, several of the builders, including Koppers Company, have developed relatively thin wall checkers containing a large amount of surface. Such checkers have assisted in reducing the waste gas temperatures leaving the regenerators, and in so doing have increased the temperature of the regenerated air or lean gas.

It is known that in all ovens the end flues require 50 per cent or more heat than do any other flues on the wall, largely on account of radiation. To provide for this additional heat requirement in a simple manner, one small crossover is connected to the end flues of the two sister walls separate from the rest of the flues, enabling the end flue to be controlled at any desired temperature without interfering with the balance of the heating wall.

IMPROVEMENT IN BRICKWORK OF THE HEATING WALL

The outstanding improvement in brickwork has been the elimination of the narrow-nosed bottle brick that has been almost universally used in the past (Figure 17). In many cases and in all types of ovens it has been found that where the old type narrow-nosed bottle brick was used and where the wall was also subjected to some distortion, such as is common with expanding coals, the bottle nose is pinched by the adjoining liners, causing spalls at the ends, these spalls in turn filled with coal. The coke resulting from the coking of this coal would not completely recede from the wall line and thus, during pushing, gouged out the adjoining liner brick. In order to eliminate as far as possible this difficulty, the hammer-head liner brick has been introduced. This brick is T-shaped, and the bottle bricks used with it consist of straight sections that touch the lower part of the T-shaped or so-called "hammer" brick (Figure 18). No such bottle bricks protrude between the liners, and the construction is such that the danger of spalling is materially reduced. This type of construction has been used for several years in Becker ovens and in Europe since 1923 by Koppers of Germany. Investigation and employment thereof over many years have demonstrated that its use is sound in practice and it also forms a stronger wall.

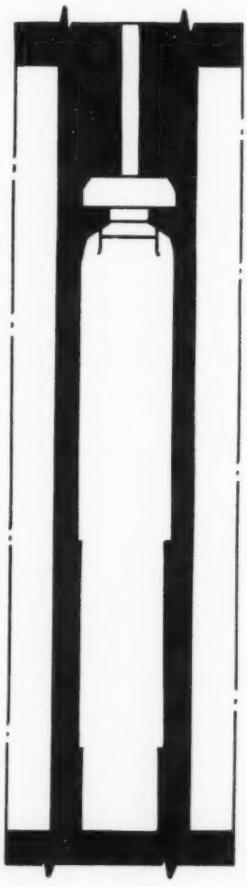
In the past, the tongue and groove was interrupted but they are now continuous thereby providing a design which adds much to structural stability and to reduction of leakage.

ACCESSIBILITY FOR INSPECTION

The newly improved Becker oven possesses the unique feature, not possessed today by any other design of coke oven being built in America, that the regenerators are open throughout from coke side to pusher side. The old Koppers oven had a vertical division wall between coke side and pusher side, and this of course was necessitated by the method of combustion. Other oven builders have split the regenerators up into even more sections and, with the exception of the old Koppers design, it was impossible to inspect the entire regenerators from the ends at both the coke and the pusher sides.

In the Becker oven everything is open for inspection and for the temperature readings made during regulation of combustion. This obtains for the vertical flues,

FIGURE 13—Becker low differential combination oven, designed for blast furnace gas firing.



for air ports, and the regenerators. There are no division walls in the regenerators and, consequently, they can be inspected from one end to the other and from either side of the battery and also from both top and bottom of the checkers, thus making it quite easy to determine their condition. In consequence, repairs, if they are ever necessary, can also be easily made. The space between the regenerator walls is large enough to permit a man to enter them and make repairs or replacements of checkers if such need is ever required.

In dividing up a cross-regenerator into many sections, the builders had, in effect, formed two or more ovens abutting each other on the crosswise axis of the oven chamber, but with the Becker design there is one wide open regenerator chamber that can be easily inspected from either side, thus providing the additional advantage that there can be no localization of gas flow and that, in case there might be a transient overloading of the regenerators at some particular spot, there will be an equilibrium established at the top of the regenerator. This means that, even though there may be some local variations of temperature in the regenerators, the temperature of the preheated air (or producer gas or blast-furnace gas) is practically the same temperature under each flue and, furthermore, that there is no forcing of air or gas or waste gas into or from an individual flue or group of flues. In other words, the entire regulation depends solely upon the air port settings, and after final setting is effected no further adjustment is necessary. In consequence, in the Becker oven, there is no juggling of gas flow between the coke and the pusher side or fractional sections thereof; the entire wall is treated as a unit and both sides are heated equally well, with a temperature gradient in conformity to the requirement of the oven taper.

BLAST-FURNACE GAS HEATING

It is not amiss to state at this point that the Becker oven was the first coke oven to be heated with straight blast-furnace gas in the United States or Great Britain. The first plants to be heated by blast-furnace gas in the United States were those of the By-Product Coke Corporation of South Chicago in the year of 1928 and the Youngstown Sheet and Tube Company at South Chicago in 1929. At both of these plants, the results were particularly successful. These plants were followed by those at the Weirton Steel Company, the Wisconsin Steel Company, the Bethlehem Steel Company at Sparrows Point and Johnstown, and the latest installation using blast-furnace gas for heating is that of the Ford Motor Company where two batteries are at present so operating and a third battery is under construction. Blast-furnace or producer gas heating in the Becker oven represents the simplest form of underfiring. Figure 12 shows a pressure survey of a Becker oven burning blast-furnace gas. As long as the gas is above 90 Btu. in heating value, a satisfactory coking rate can be obtained. When once the battery is set for drafts and fuel-gas pressure, no further regulation is necessary, and there is practically no labor required for heating operations beyond the usual routine inspection. The whole battery or any single oven can be quickly and easily switched from lean gas to high Btu. gas heating without any internal regulation. Gases of less than 90 Btu. may be supplemented by high Btu. gas, either by mixing directly with the lean gas or by introducing it through the guns directly or also through the rich gas distribution system in the regenerator walls wherever underjet ovens are used.

Briefly summarizing, the outstanding advantages of the Becker oven over other types of ovens are as follows:

A. Low-differential oven.

B. Simplicity of construction and design. A crossover is provided for every set of four flues, thus providing low differentials of pressure throughout the combustion system. Sliding brick has been eliminated and the air or lean gas is properly proportioned by means of sillimanite cylinders or plugs placed concentrically in the combined air and gas ports. Once set, they are never regulated.

C. With improved regenerator design, the waste gas temperatures are lower and the heating of the end flues has been improved by allocating one crossover to each end flue.

D. In all the later Becker ovens, the oven heating walls are built with the so-called hammer-head type of liner bricks, to the exclusion of the old type of weak bottle-nose brick.

E. The regenerator is continuous from one battery side to the other and the whole may be readily inspected at any time.

F. Nothing in the interior of the oven is hidden from the eye, as is the case in other constructions.

G. The open regenerator allows the entire wall to be treated as a unit and there is no juggling of gas flow between coke and pusher sides.

H. In the case of shutdowns, the Becker oven, because of its freedom from complicated counterflow passages, its accessibility accorded to all parts of the structure, and its low differential, will upon reheating show the least effect of a shutdown.

PRESENT TRENDS IN COKE-OVEN DESIGN

The trend at the present time is toward an oven width of from 16 to 18 inches. During the past thirty years considerable experience has been gained operating ovens having a width of from 12 to 21 inches. It is well known that ovens approaching a width of 21 inches have a reduced throughput per inch width, while on the other hand, with the narrower ovens the throughput per inch of such dimension can be materially increased. Narrow ovens produce a coke of more uniform cell structure and give higher by-product yields. It is necessary to coke some coals in narrow ovens to produce satisfactory coke. On the other hand, narrow ovens offer certain operating conditions which may be objectionable, such for example as the increased number of operations, lack of accessibility in case of repairs, etc. The most practical width of oven found for most coals used in the United States lies between 16 and 18 inches. Such ovens appear to give the least operating difficulty, can be built strongly, and are probably the most all-round satisfactory ovens to operate.

The present length of oven is in the neighborhood of 40 to 42 feet and their taper is from 2½ to 4 inches,

depending upon the kind of coal mixture used. The larger taper is used for ovens in which larger quantities of low-volatile coal are carbonized. However, it should be remembered that this is in no sense a cure for the use of expanding low-volatile coals. It merely aids in starting the pushing.

An oven such as that built for the Ford Motor Company and which is 17½ in. average width, with a 3 in. taper, a length of 40 ft. 3½ in. between doors, is 13 ft. 3 in. high, with a 12 ft. 3 in. coal line, will contain 720 cubic feet, and with a coal weight of 50 pounds per cubic foot, the oven will hold 18 tons. Operating at 17 hour coking time, this oven will handle 25½ tons of coal per day. This represents what might be considered the average sized oven. We believe all authorities will agree that it is not good practice to go much beyond a 13-foot coal line. Experience seems to indicate that the practical and economic limit of height of oven chamber is in the neighborhood of 14 or 15 feet.

UNDERJET OVENS

This paper would not be complete without comments relative to the principal features of the Becker underjet oven. There is some appeal in the use of the underjet method of feeding coke-oven gas to the flue versus the horizontal gun-flue method.

In the gun-flue construction, the old clay nozzles were always a source of trouble largely as a result of their tendency to swelling and deformation under the influence of heat. This condition has been eliminated by the introduction of the sillimanite nozzle but is is true, nevertheless, that if a radical change is made in coking time there should be some change in nozzle settings, and this is always a laborious procedure since such operation must be effected from the top of the battery. Feeding the gas to the flues by means of the underjet ducts eliminates the necessity of patching the guns, and in event that a radical change in coking time is demanded, the regulation of the gas can be easily carried out from beneath the oven.

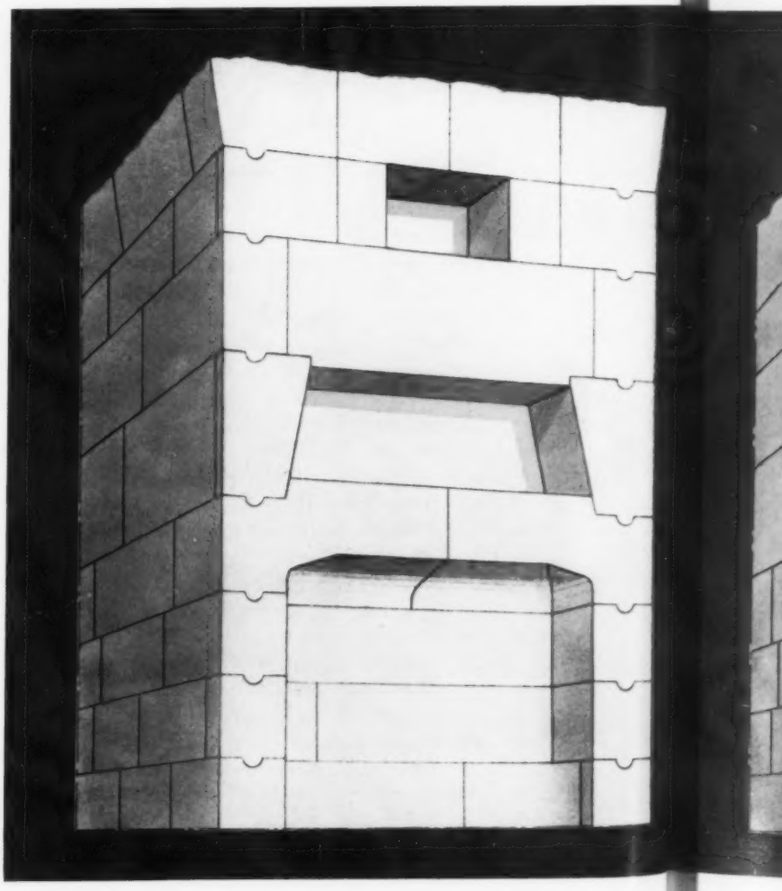
The underjet system should not be used in ovens where there is a counterflow between the waste gas and the upwardly-flowing fuel gas. The Becker oven is the only oven in which there is absolutely no opportunity for counterflow between the upflowing fuel gas and the downflowing waste gas. This cannot be said of any other type of oven. For example, in the modified double-divided Koppers oven described earlier in the paper, builders have attempted to circumvent this condition by the introduction of waste gas sole flues lined with alloy steel. The inadequacy of this practice has already been discussed.

The construction of coke ovens taking place in the United States at the present time is both for expansion of production and also for rebuilding of older batteries. In most cases of rebuilding, the old mat and foundation are in such good condition that new ovens can be and have been built on the old foundations. In such cases, it appears uneconomical to expend capital to tear out good foundations and build underjet ovens. However, if new foundations must be built, underjet ovens should be given consideration. To many engineers, the facility of accessibility provided by underjet ovens in the passageways beneath the entire structure makes a strong appeal. The underjet oven has, under some conditions, certain structural advantages such as:

A. In case the ovens are built on a site where ground conditions are bad and deep foundations are necessary, the underjet ovens, which rest on columns, offer structural advantages.
B. An oven that is supported on columns operates with a cooler mat than the oven built directly on the ground, and the mat temperature can be controlled by ventilation through the inter-column spaces.
C. In the construction of underjet ovens it is a simple matter to provide expansion joints in the mat and thus entirely prevent overall expansion of the mat.
D. The underjet oven is more amenable to quick changes in the type of heating gas employed and can be changed from coke-oven gas to blue, water, or natural gases with great simplicity and with the proviso that the distribution header is so designed as not to require any change in the orifices that regulate flow to the flues individually.

It is obvious that there is no advantage one way or the other in the underjet type of oven when using pro-

FIGURE 14—Sectional view through Becker low differential oven horizontal flue.



ducer gas or blast-furnace gas. It is also obvious that when using the underjet system of underfiring *the coke-oven gas must be clean.* It must be free of tar and gummy materials. If this is not the case, then the labor of cleaning the regulating devices may offset its advantages.

A considerable number of Becker underjet ovens have been built but so far no important distinction has been noted, in the heat requirements for underfiring, between the Becker Low-Differential Gun type oven and the Becker Low-Differential Underjet Oven, because comparable operating conditions and ovens of equal size and operating at the same coking time, etc., were not available.

One other important improvement that is coming to the foreground is the use of a single waste-gas canal for carrying the waste gases from the regenerators to the stack. This, of course, simplifies the entire reversing equipment, cutting in half the necessary gas boxes and also the air or lean gas boxes, and such practice of course has the advantage of simplification. This design is now satisfactorily working in several plants.

SELF-SEALING DOORS AND IMPROVEMENTS IN OVEN MACHINERY

The entire trend of such equipment is today toward self-sealing doors and the appropriate machinery to handle them. The outstanding self-sealing door offered to the trade today is the Koppers-Wolff self-sealing door. The Koppers Company has built hundreds of self-sealing doors and of various types ever since the organization of the Company in this country. They have tried experimentally various types of iron-to-iron joints as well as doors using asbestos rope sealing, and have equipped a number of smaller Becker ovens at gas plants with self-sealing doors having metal-to-metal contact. Several such door installations have been in satisfactory operation from 10 to 15 years at Battle Creek, Flint, Jackson, and Saginaw, Mich. However, after several years of experimentation with them at Boston, all the recent Becker ovens have been equipped with the Koppers-Wolff self-sealing doors, and they are to be found in the plants of the Public Service Electric and Gas Company, Camden, N. J., Ford Motor Company, Detroit, Mich., Tennessee Coal Iron and Railroad Company, Fairfield, Ala., Inland Steel Company, Indiana Harbor, Ind., Colorado Fuel

FIGURE 15—Section through Becker low differentia oven horizontal flue, showing support of brickwork at top of horizontal flue.

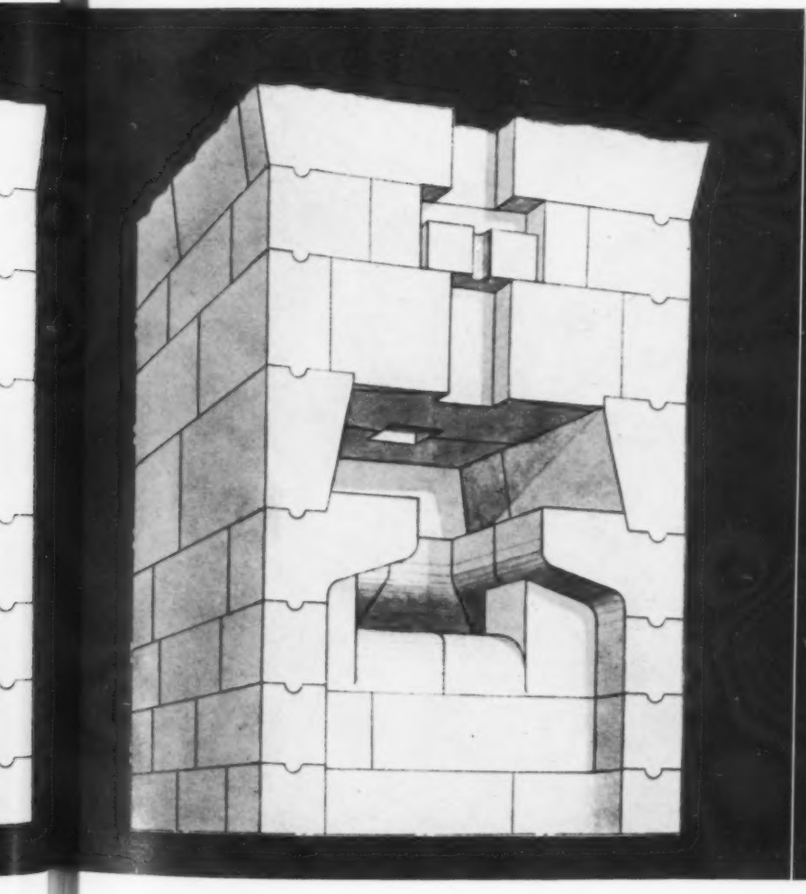
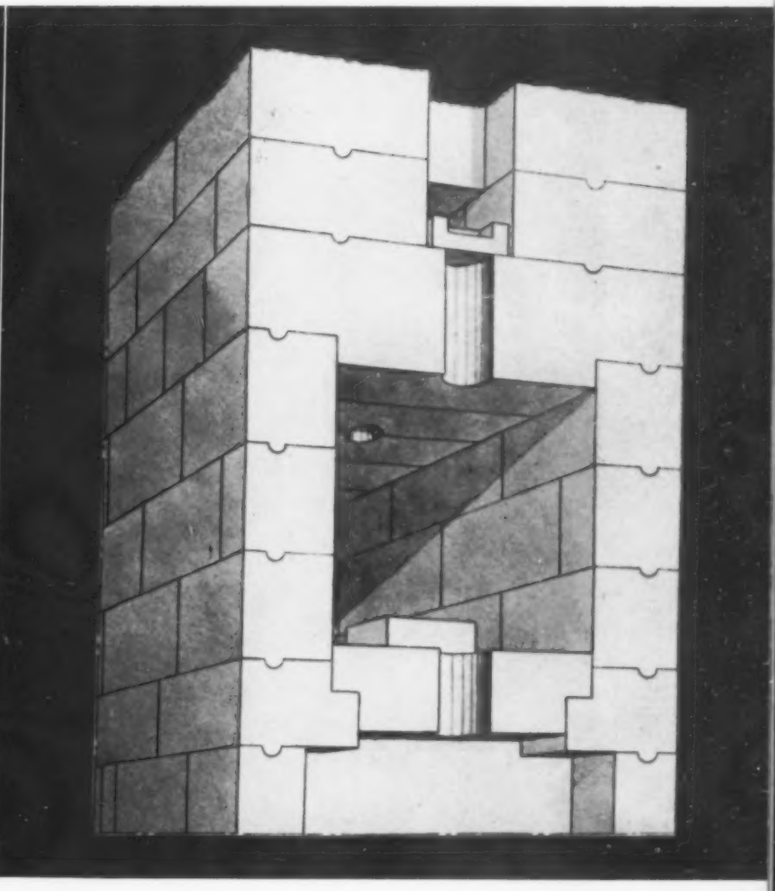


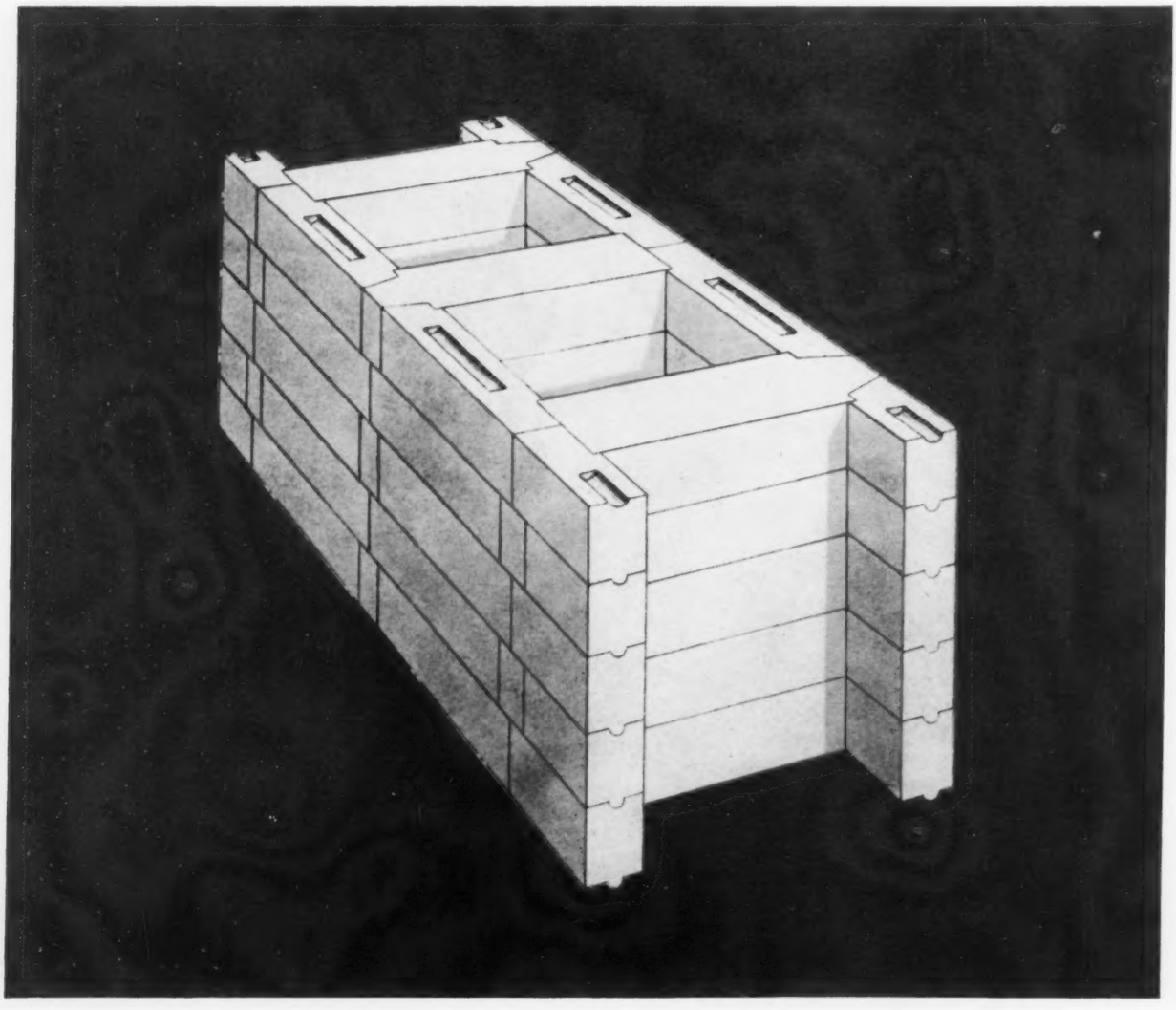
FIGURE 16—Sectional view through horizontal flue in the old Koppers oven.



and Iron Company, Pueblo, Colo., and Republic Steel Corporation, Youngstown, Ohio. In all of these plants these doors are giving good service. They have eliminated the old arduous job of door-luting, which is particularly satisfying to both management and labor, especially in the summer time. There is considerable saving in labor costs for operating. The operation and maintenance of mud mills, mud buggies, and mud elevators are no longer necessary. The doors in all of these plants are handled by automatic door-machines. That is to say, the door rack moves out, engages the door, and loosens the latches by means of a special type of motor-operated gripper. There is a small amount of cleaning to be done on the knife edge and on the jamb frame but this can be quickly and easily carried out. The doors after being withdrawn are easily accessible in all parts so they can be more readily cleaned, all of which makes the work of the operator easier and subjects him to less heat. This is a decided improvement over the old door-machines and is worthy of consideration for plants now using mud-luted doors.

The larry cars of today are largely of the bridge type enabling workmen to walk under the cars and to manipulate the charging lids with ease. Some are equipped with Koppers' smokeless-charging piping which interconnects the charging holes with special hoods located below the discharge valve on the hoppers. These ducts carry the smoke from one side of the oven to the other at the same time that suction is being applied to the standpipe by means of steam jets. Other plants favor the Koppers system of smokeless charging known as double collecting-main charging. That is to say, both coke and pusher sides are equipped with collecting mains and these two mains are interconnected before a master pressure controller. The oven is usually equipped with three charging holes and both standpipes are connected to the main during the time charging takes place, thus releasing the gases to each main simultaneously. Each oven standpipe is equipped with a steam jet which will cause a small suction condition to exist within the oven and thus prevent any outflow

FIGURE 17—Construction using the old bottle brick was subject to spalling.



of smoke or gas. This has completely solved the smoke nuisance problem to the benefit of both the plant and the surrounding neighborhood.

CONCLUSION

This paper has summarized a large number of facts which should be taken into consideration when a coke-oven plant or battery is going to be built. The preliminary considerations of the coals to be used and the coke to be made have been briefly discussed, considerable stress has been laid on causes of oven deterioration, an attempt has been made to analyze the causes of oven failures along with a discussion of their remedies provided in the newer designs, and a critical study has been made of what is probably the most nearly ideal oven.

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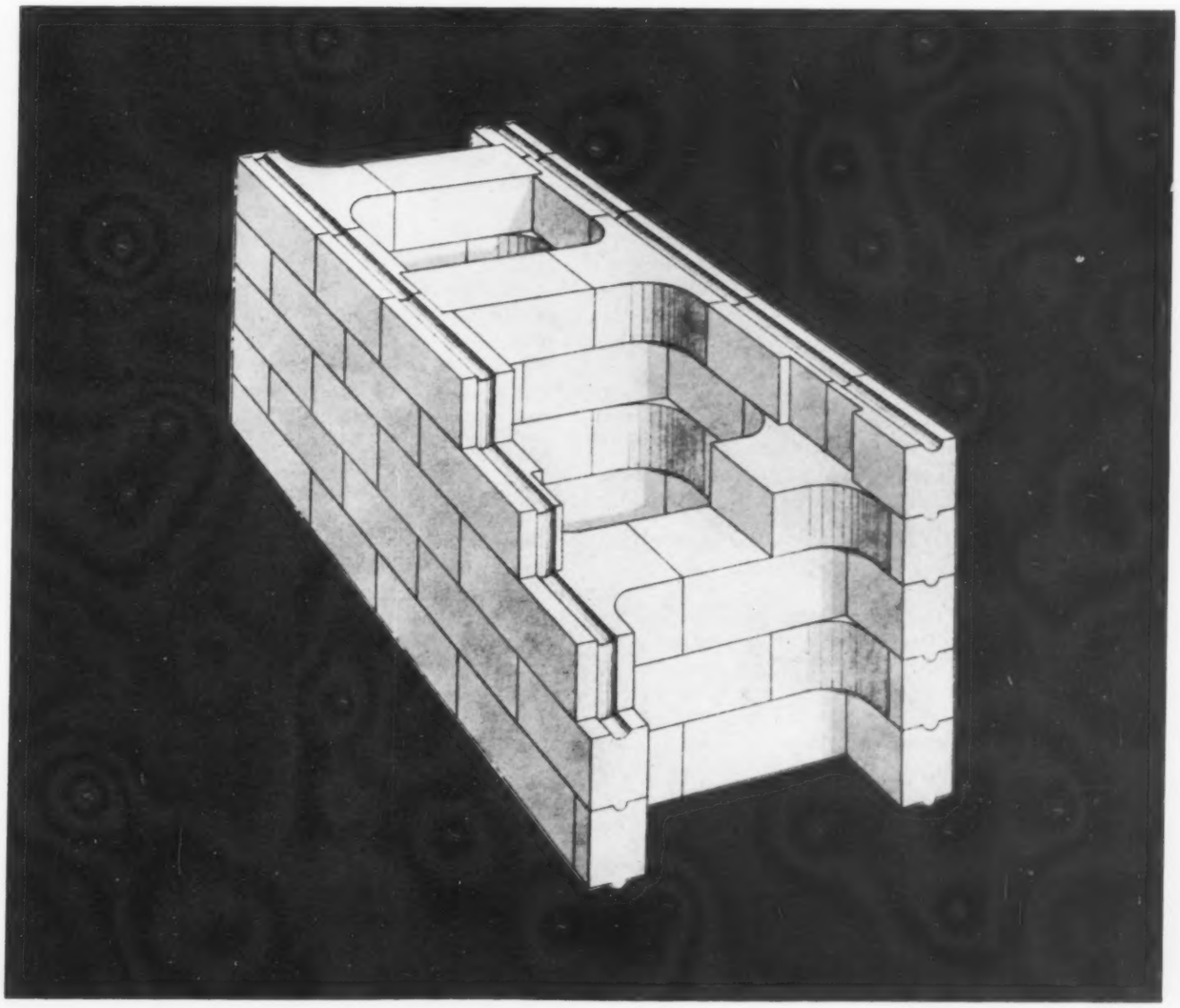

FIGURE 18—New hammer head brick construction has been used for some time, and forms a stronger wall.

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DISCUSSION

PRESENTED BY

M. D. WALD, Superintendent, Coke Plant, Republic Steel Corporation, Cleveland, Ohio.

R. W. CAMPBELL, Superintendent, Coke Plant, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

E. J. GARDNER, Superintendent, Coke Plant, Inland Steel Company, Indiana Harbor, Ind.

FRED DENIG, Vice President, Engineering and Construction Div., Koppers Co., Pittsburgh, Pa.

M. D. WALD: Mr. Denig has outlined the important factors to be considered in the building of a coke oven plant, and has shown how some of these considerations have led to the present design of the Becker oven. He is to be complimented on his very able presentation of the subject. The new oven has many important developments and should give eminently satisfactory results. It is more rugged in construction, provides better control of heating, and is free to a greater extent from cross-leakage than any of the previous designs.

Mr. Denig points out the need for thorough study of the coals to be used in the operation. It would be well also to give attention of the design of the coal handling plant that is to prepare the coal for coking. Coals vary widely in hardness and in coking characteristics. Sometimes there is wide variation in the coking properties of the coal from an individual seam. Uniformity is one of the first requirements of metallurgical coke. Yet frequently there is found a marked lack of uniformity in the coal mixture delivered to the storage bins, with the result that within the oven there exist zones of varying coking power. No amount of care on the part of the oven designer to insure uniform heat distribution can compensate for irregularity in the coal. It is important that the mixing plant should mix the coal thoroughly and completely. Storage bins should be designed with a view to preventing segregation of the coarser particles. The nature of the coals will of course determine how uniform will be the coke from oven to oven or from day to day, but insofar as irregularities in the coals permit, the coal handling plant should be built to deliver a coal charge that will be uniform throughout the oven.

With reference to locating the upper terminal points of the heating flues properly for the coal to be used, the question arises as to what would happen if a change is made from a coal with a high vertical shrinkage, for which the location of the flues was originally determined, to a coal or coal mixture having but slight shrinkage. Would the result be "black tops," as in the old Koppers oven when the horizontal flue was located too low? It would seem advisable not to risk such a condition, but rather to locate the ends of the flues sufficiently high for any coal that might be used, and to rely on controlling the heating to give the desired temperature at the top. The width of the oven governs the yield and character of the by-products to be obtained perhaps to a greater extent than does the lower temperature at the oven top. Where high tar yields are desired the oven should be built narrower. For high gas yields the wider oven should be chosen.

Mr. Denig's analysis of the causes of oven destruction is very interesting. But there have also been cases of serious damage that were not due to the use of expanding coal or to overheating through carelessness or through leakage. Damage has resulted also because of the failure of some ovens to withstand the shocks of sudden and frequent changes in operating rate encountered in steel plant operation. Under this paper's caption, "What is Needed in a Modern Coke Oven," an operator might add: An oven that will withstand the fluctuations in operating conditions without deterioration. So well had the old Koppers oven performed in this respect that the question is sometimes raised as to why build any other type. Were it not for the fact that the Koppers oven does not meet present day requirements, as Mr. Denig explained, it would be difficult to justify any different oven. Actually it is not necessary to return to this early design. With the same care in handling the Becker low differential oven should have a life equal to the best of the old Koppers ovens.

A valuable service was rendered coke oven operators by the development of self-sealing doors. The work has been made much easier and cleaner also by improvements in oven machinery and in the method of charging. Taken altogether the new oven makes possible important savings in operating costs.

R. W. CAMPBELL: Mr. Denig is certainly to be congratulated for his very interesting and instructive paper on "Modern Coke Oven Design and Practice",

and has very ably pointed out many very important points to be considered by both the designer and operator of coke ovens.

During the "Depression" and the so-called "Recession" all coke plant operators have been called upon to operate ovens under conditions which ten years ago would have been considered an absolute impossibility. There can be no doubt that the operators themselves have gained much valuable information regarding the weak points of the various types of coke ovens used in this country, while subjecting them to extreme variations in coking time, keeping them idle and warm, and in some cases allowing them to go cold. It would make a very interesting "Buyers' Guide" if the summation of all of these experiences and information could be compiled and made available to those confronted with the problem of building a new plant or rehabilitating an old one.

I agree with Mr. Denig that in the past and unfortunately at the present time, that not enough thought and study has been given by all coke oven operators to the type or types of coal used in producing metallurgical coke.

At our plant, in addition to laboratory, chemical and physical tests on all coals or coal mixtures, we make one or more actual oven tests by charging the coal or coal mixture from a 100-ton experimental bin. Complete chemical and physical tests are then made on the coke produced and the decision is then made whether it is advisable to use this coal or coal mixture in daily practice.

Many so-called failures of different types of coke ovens in this country have been the fault of the operator and not the designer and builder, due to the use of coals different than that for which the plant was designed, or idiotic operating conditions which no heap of silica and clay bricks could possibly withstand.

In closing I would appreciate having Mr. Denig answer the following questions:

1. Is it true that the waste heat flue crossing over the top of the oven in the Becker type oven would tend to give a lower yield of light oil and tar with the same coal mixture, oven width and coking time than that obtained from the old type Koppers Oven?

2. Is it not true that the underjet type of oven is apt to develop gas leaks in passing through the brick work from below the battery to the vertical flue?

It has been my experience with one type of oven where decarbonizing flues were carried from a main duct up through the regenerator walls to the gas guns, that gas leaks developed in the regenerators and necessitated the plugging of these flues with silica sand and the adoption of decarbonization from the end of the gas gun.

3. Is it not true that in order to secure better vertical heat regulation the Gary people experimented with high and low burners on the first two Wilputte underjet batteries and with only low jet burners on the first two Koppers Becker Underjet batteries, and subsequently discarded the high burners and came back to the low jet on the present Wilputte ovens under construction, a similar burner arrangement as in Becker Ovens at Gary?

E. J. GARDNER: No doubt, with the number of Coke Plants that have been built in the United States and foreign countries, managers, engineers and operators have considered and planned the greater part, if not all, of the points brought out by Mr. Denig, as to the design, construction, coals to be used, oven machinery, etc., but I have never heard or read a paper in which the facts to be considered in building a battery of ovens were so logically set down, and so clearly described as in this paper by Mr. Denig. In fact, Mr. Denig has covered his subject so thoroughly that it leaves very little for anyone to add.

Being an operator of a plant where all the coke, after screening out the Domestic and Braize sizes, is used for blast furnace purposes, naturally, my remarks will be confined to oven design for blast furnace use.

On Page 2—under the heading of "Coals."

I would not only make the tests set up by Mr. Denig, but in the case of making blast furnace coke, if no ovens were availably at my own plant, I would have at least 20,000 tons of the coal to be used, carbonized at a plant of a design similar to what I was considering and see the effect on the blast furnaces, because, after all, the final test on the coke is the results obtained at the furnaces.

I agree with Mr. Denig that the simpler the oven can be built, the easier it will be to operate the heat under normal coking time. But we have found that during the past 6 or 7 years our operation and coking time have not been as uniform as in previous years, and that the battery being designed today should be made flexible in order to take care of these vibrations.

Mr. Denig also states in his paper the experience gained on ovens having a width of from 12 to 21″. Up to 1937, Inland had one battery of old Koppers design with an average width of 18″ and two batteries, Becker design, of an average width of 16″, and with the building of the low differential Becker ovens in 1937, the question arose as to the width. It was decided that on account of the blast furnaces wanting sized coke, it would be necessary to start with a coke large enough to be sized, and therefore an average 18″ width oven was built.

I wish to state that we have operated this low differential Becker oven since November 1937, the shortest coking time being 18 hours, and we find the battery produces a very uniform coke and that the underfiring is lower than on our other batteries; also, that the self-sealing doors are very satisfactory, even operating under a back pressure as high as 8 mm.

Mr. Denig states, "Many plants find that a significant increase in coking time changes the quality of coke and thus disturbs the coke practice." If I may assume that this remark refers to coke practice of a blast furnace, I venture to say that all coke and blast furnace men will agree that a *significant* increase or decrease in coking time will have that effect, but I wonder just how many facts are known and can be proven about *any* irregularity, be it increase or decrease of coking time. Do delays, for instance, in pushing, due to a breakdown in any part of the coke plant system have a proven effect? A breakdown frequently requires that pushing be stopped for an

(Continued on page 63)

EUROPEAN *Welding* PRACTICE *and* AMERICAN TRENDS

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▲ WELDING in European countries is in a state of rapid development the same as it is in the United States. Many companies are using welding extensively and doing the highest quality of work. Other companies, as in the States, are just beginning to realize its merits and are consequently only starting to capitalize on its many advantages.

In order to properly discuss European welding practice it is desirable to briefly discuss a number of important economic and industrial conditions that have and will continue to have an important bearing on this fabrication process.

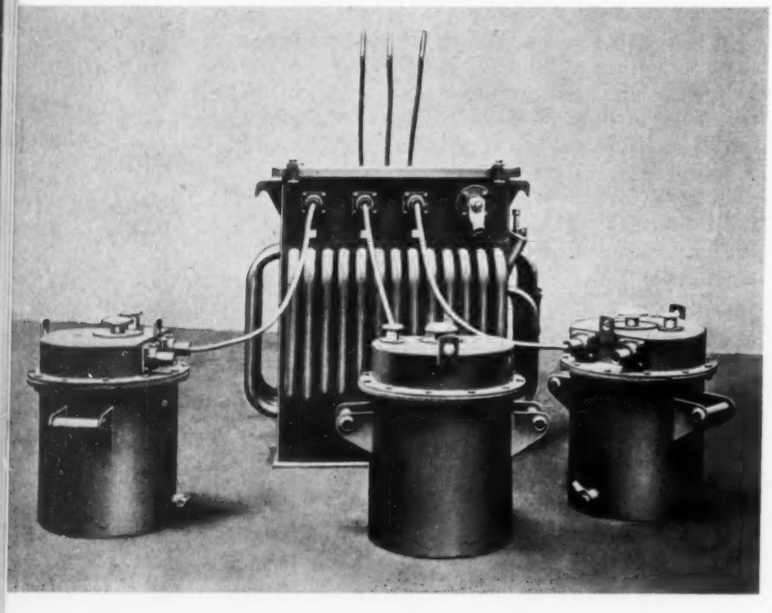
(1) Production in Europe is generally not as large as it is in the United States, consequently there is not the demand or economic advantages of many of the expensive welding processes in use in the United States. This probably accounts for the more rapid development and extensive use of special welding processes in America.

(2) Design details are often specified by the purchaser and each purchaser has his own requirements. Consequently, it is not as easy to standardize on design as it is in the United States. This condition interferes with high production items.

(3) Wage scales of European workers are lower while raw materials are somewhat higher than they are in the United States. This condition makes it uneconomical in many cases to use many of the labor saving devices, such as welding manipulators which are common in the United States. The application of work handling tools is increasing, however, and a marked change will take place in the near future.

(4) Many of the materials in use in America are not commonly available in Europe, consequently the engineer does not have as much to choose from in designing a structure.

FIGURE 1—This multiple operator a-c. welding set, manufactured in England, differs widely from those manufactured in America.



ARC WELDING

A. *General*—Arc welding is the most widely used welding process in Europe as is the case in America. The types of welding machines and electrodes used, although different in minor details, are quite similar.

In England a-c. welding machines are more widely used than d-c. machines. Several years ago nearly all welding machines were of the a-c. type, although at the present time the ratio of new machines sold is about 60 per cent a-c. and 40 per cent d-c. In view of the

Mr. C. H. JENNINGS presenting his paper before the A. I. & S. E. thirty-fourth annual convention at Cleveland, Ohio September 27, 28, 29 and 30.

present trend it may be expected that before many years there will be as many d-c. as a-c. machines sold.

The reason for the larger percentage of a-c. machines in use can possibly be attributed to several things.

1. A-c. welding machines are inherently less expensive than d-c. welding machines. Industry in England does not spend as much money on equipment as is the case in America, consequently a-c. machines are preferred.
2. Coated electrodes are used almost exclusively in England and have been for many years. Properly designed coated electrodes work satisfactorily on a-c. machines, consequently they have fostered their use.
3. Power systems are somewhat different than they are in America and in many cases it is impractical to start a motor generator set by throwing it directly across the line. This means special starting equipment which is not required with a-c. type machines.

In Holland about 80 to 90 per cent of the welding machines are of the a-c. type while in Germany this order is reversed. In France both types of machines are used as is the case with other countries.

In Holland nearly all electrodes are of the coated type while in Germany the major portion of the electrodes are of the bare types. In France both bare and coated type electrodes are used as well as large quantities of washed and light dipped electrodes. Cored type electrodes are also frequently used on the Continent.

The bare type electrodes used in Germany are probably the prime reasons for the predominance of d-c. welding equipment. The trend in Germany is undoubtedly toward coated type electrodes but at the present time their most extensive use seems to be confined to companies manufacturing electrodes for their own personal use.

The possible explanation for the extensive use of bare type electrodes in Germany lies in the fact that they are accepted by the German State Railways and the Admiralty. Inasmuch as these two organizations are considered to be leaders in engineering, others tend to follow.

A somewhat similar event occurred in the United States a number of years ago which was largely responsible for the rapid adoption of coated electrodes in this Country. This was the adoption of welding by the A.S.M.E. Boiler Code which required coated electrodes for the highest quality welding and the exclusive use of coated electrodes by the U. S. Navy.

In addition to the standard a-c. and d-c. welding machines the rectifier set is becoming more popular, especially for light gauge work. This type of set will probably grow in popularity as more experience is gained with it.

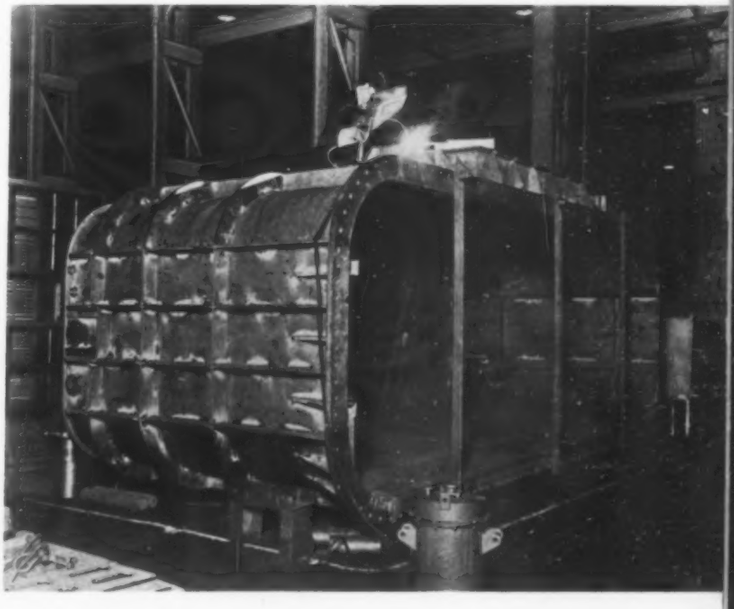
B. *Welding Machines*—As mentioned previously, the design principles of most European welding sets are similar to those of American manufacture. The external appearances are, of course, much different.

There are two welding machines manufactured in England which are worthy of special mention because they differ widely from those manufactured in America.

One is a multiple operator a-c. set operating on three-phase power (Figure 1). A three-phase transformer is placed across the line to which adjustable reactors are attached. Each reactor represents a welding station and allows a welder to work independently of the others. As many as 12 reactors may be used in combination with one transformer.

The other is known as an a-dc set and is also a multiple operator set. This welding set is of the constant

FIGURE 2—Welding designs, such as this arc welded tank for a 45,000 Kva. transformer, are applied in Europe as well as in America.



potential type and operates on 40 volts d-c. In order to obtain sufficient voltage to strike the arc a higher a-c voltage is superimposed across the arc. As soon as the arc is established the a-c. voltage is cut out and the 40 volt d-c. power is used for welding. The advantages claimed by this system are small size welding equipment and reduced losses.

Special attention has been given to the design of a-c. welding machines for welding with light gauge electrodes and a number of sets are available which will operate satisfactorily on currents as low as 20 and 30 amperes.

The rectifier sets are generally of the glass tube type, the designs of which are such that little or no troubles are experiences from breakage from normal shop handling.

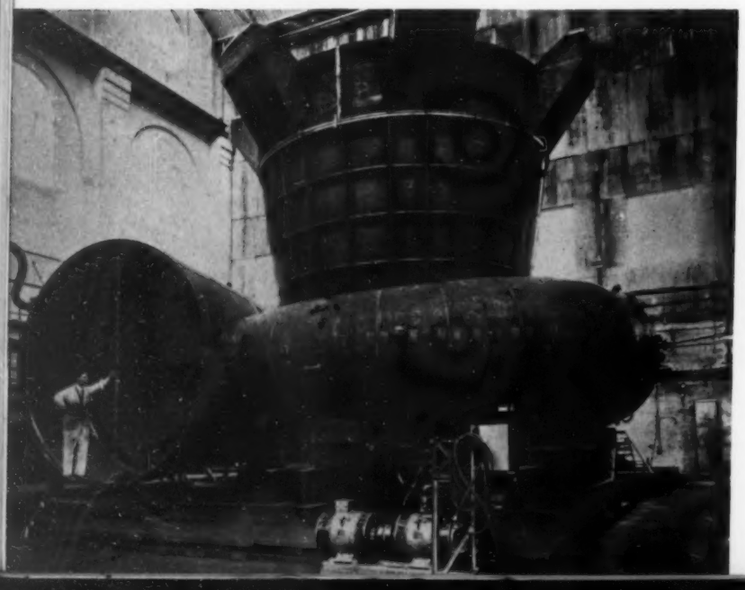
C. *Electrodes*—There are many types of electrodes manufactured in Europe. These electrodes comprise nearly all the types manufactured in America in addition to many others. Special attention has been given to the development of cored electrodes on the Continent. Special bare type electrodes have also been developed in Germany which produce welds of greater soundness, tensile strength and ductility than the bare type of electrode found in America. Electrodes of this type will produce welds with 70,000 lbs./sq. in. tensile strength and 25 per cent elongation.

One point particularly noticeable in England in connection with electrode development is the effort being made to develop small gauge a-c. type electrodes. Electrodes $\frac{1}{16}$" and smaller are not uncommon and butt welding on 24 gauge plate can be accomplished with a-c. machines without the use of a back-up.

Carbon arc welding is becoming very popular for thin plate welding and the results obtained are very satisfactory. This work is being done both manually and automatically. Special electrode holders of the carbo-flux type are used. This holder consists of a small coil built in the carbon holder which produces a magnetic field around the arc and concentrates it at the desired point.

D. *Automatic Equipment*—Relatively few automatic arc welding machines are in use in Europe al-

FIGURE 3—This all-welded 11,000 kw. spiral casing and generator support is an English design.



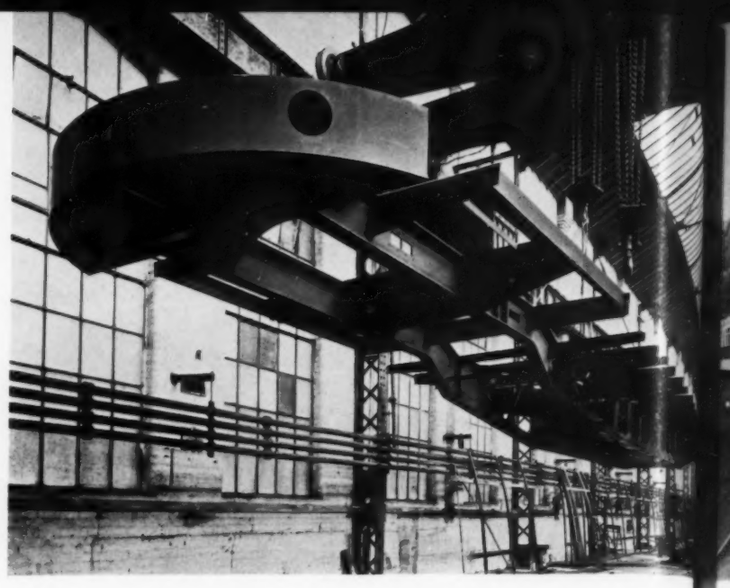


FIGURE 4—All-welded underframe for a Ceylon rail power coach.

though there is a great interest in the subject at the present time. There were approximately six different types of automatic arc welding machines on display at the welding exhibit in London.

One machine was of the type used in America where the flux coating is slotted to permit current conduction to the electrode.

Several automatic carbon arc welding machines were on display. Arc shielding with these machines was generally obtained by means of an impregnated paper rope being fed into the arc.

One automatic metallic arc process consisted of feeding short lengths of coated electrodes the ends of which were screwed together by means of a special alloy conductor, in order to make a continuous electrode. This conductor acted as the current carrying part and passed through the arc without producing flaws in the weld.

Another automatic metallic arc process employed an electrode manufactured in Holland which consisted of a central wire around which a small spiral wire was wound. The thickness of the flux coating on the central wire was equal to the diameter of the fine spiral wire. A thin steel tape was finally wrapped around the flux coating and spiral wire. This electrode possessed good current carrying characteristics, was flexible and produced sound ductile welds. The design of this electrode was such that it could be used on nearly all standard automatic welding heads suitable for bare electrodes.

A simple semi-automatic welding head that has been developed in Holland is also worthy of mention. This head consisted of a variable speed motor to feed the electrode and a long flexible tube leading from the motor to the electrode holder. The motor was equipped with a speed control rheostat and the holder was equipped with a control switch. To operate this equipment the motor speed is set to feed the electrode at a rate slightly faster than it is consumed. When the electrode extends too far through the holder the motor is shut off until the electrode melts back to the proper length. At this point the motor is again switched on.

In this equipment the arc length is controlled by the operator and the only advantage is the use of continuous electrodes.

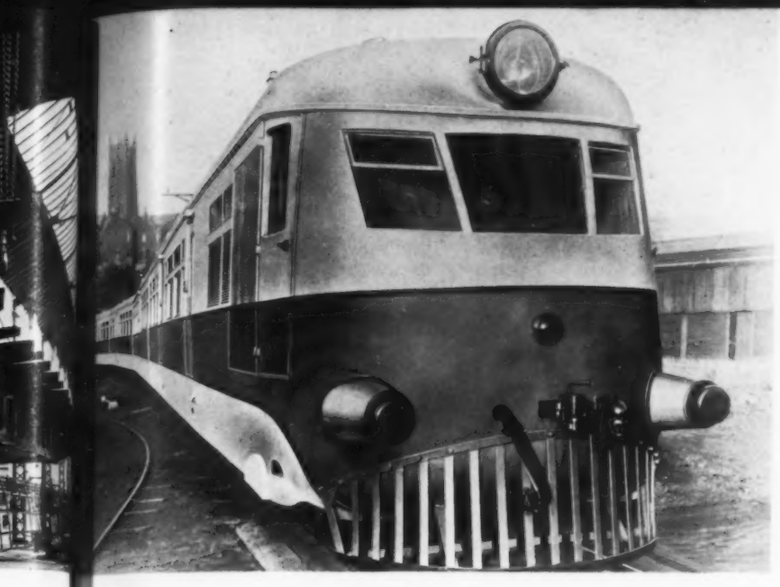


FIGURE 5—Completed view of a Ceylon 4-car articulated train, completely welded.

DESIGN PRACTICE

General design practice in Europe is similar to that in use in the United States. The external appearance of much of the apparatus is, of course, quite different but a close analysis indicates a great similarity of points.

The most striking point in design was the large variety of products and items that are designed for welding. Many small items are all arc welded even though this process does not appear to be the most economical. There are several possible reasons for this condition.

1. It may be assumed that the use of welding is in the stage which many American industries passed through several years ago. The advantages of welding become so obvious after it is used a while that designers become over-enthusiastic and attempt to weld everything.
2. A second reason is the limitations of other satisfactory methods of manufacturing small or complicated parts. Delivery dates are important, consequently it is impractical to have castings made in many cases even though it might seem more desirable. Most companies do not have equipment to make pressings and die cost and and deliveries from outside suppliers again exert a tremendous influence. Also the low labor cost and production makes it impractical in many cases to make expensive tools for forming parts.

Another important design item is the extensive use of parts even on large equipment. It appears as if not enough time was given to a thorough analysis of the problem in order to eliminate unnecessary parts. A possible lack of experience of some designers regarding the strength of welded structures is one possible reason for this condition.

The inability in the past to obtain large steel sections has often required the designer to build up parts from smaller sections. This condition, although unavoidable, requires large amounts of welding which would otherwise not be required.

Welding designs have been applied to many types of engineering products in Europe the same as in America. Figure 2 illustrates welding as applied to a 45,000 kva. transformer tank while Figure 3 illustrates an all-welded 11,000 kw. spiral casing and generator support assembly for the Galloway Water Power Company (Scotland).

All-welded railway coaches are becoming very common. Figure 4 illustrates a welded underframe of the power coach of a 4 car articulate train for Ceylon. A completed view of the Ceylon train is shown in Figure 5.

WELDING PROCEDURE

In general the welding procedures used in Europe are quite similar to those used in America. They are found to vary in detail between countries and factories, however. The most important factors regarding procedure practice may be enumerated as follows:

(1) Electrodes in use are similar in purpose and application to those in America. Downhand, fillet weld and position type electrodes are in common use. Wherever possible work is tilted to facilitate faster welding.

(2) Many plants still have old equipment with maximum current ratings of 150-200 amperes. In such cases small diameter electrodes are still used exclusively. This condition is changing, however, but there are still a lot of small machines in use on heavy work. The modern plants have equipment suitable for 1/4, 5/16 and 3/8 inch electrodes. In cases where large machines are available, large electrodes are used as frequently as in the United States.

(3) Most factories do not have manipulators for handling welding work although a great interest is being shown in this field. The Werkspoor Company in Holland, however, have developed special manipulators for rotating complete rail coaches and bogies as illustrated in Figures 6 and 7.

(4) Annealing of welded structures is seldom done in Europe except for pressure vessels and parts which must not distort. Rotating equipment, railway bogies and underframes are seldom if ever annealed before being placed in service.

(5) There is a notable trend in Europe toward fabrication of structures from pre-machined parts in

FIGURE 6—A complete rail coach may be rotated in the welding manipulator to facilitate downhand welding.

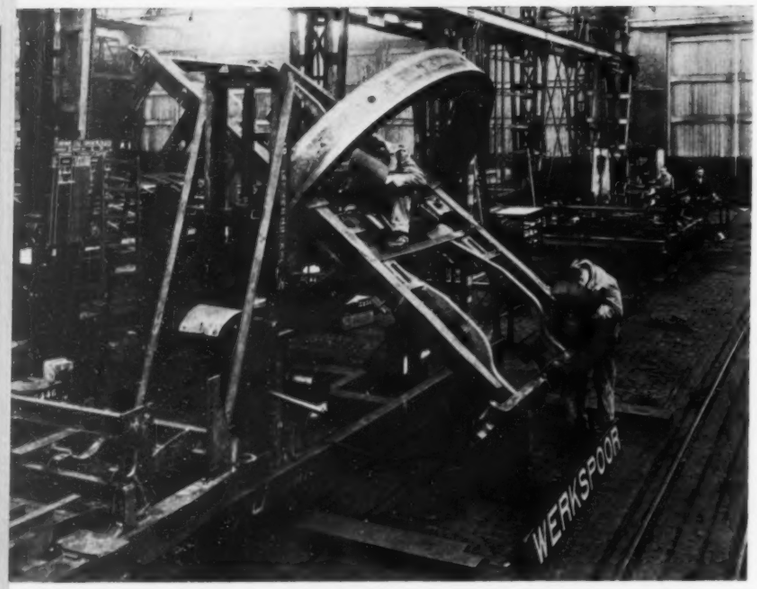


FIGURE 7—The use of manipulators for handling welding work is not widespread in Europe, although considerable interest is shown in this field.

FIGURE 8—This water wheel contains electric welded stainless steel overlays on cast steel plates.

order to eliminate expensive final machining. Structures of this type have been fabricated by the English Electric Company within tolerances of .008″. Work of this type requires accurate heavy fixtures and very close welding procedure and control.

(6) Extensive use is being made of plates in place of rolled sections. This condition is created partly by the inability to obtain large rolled sections. In Germany special rolled sections are available for fabricating certain classes of structures such as heavy beams.

(7) Alloy welding is not as advanced in Europe as it is in America. There is, however, considerable alloy welding being done and this phase of welding is developing rapidly. Figure 8 illustrates a water wheel containing electric welded stainless steel overlays on the cast steel blades to prevent erosion caused by cavitation.

SPOT WELDING

Spot welding is not used as extensively in general engineering work as it is in America. There is a great interest in this method of welding, however, and within the next few years a marked development will be seen.

The auto industry is probably the leader in spot and resistance welding with the railway industry running second.

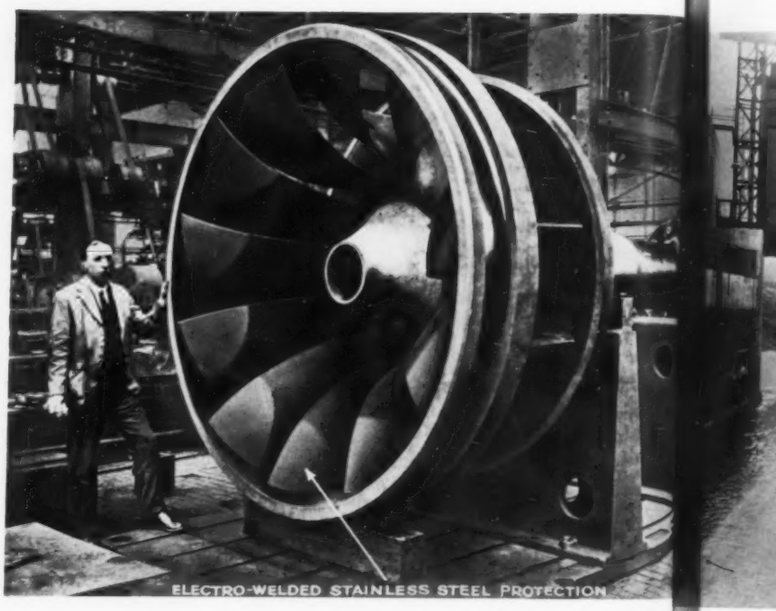
Special spot welding machines of the percussive welding type have been developed which use direct current. These machines also employ variable electrode pressure to obtain the best results. High pressure and current is first applied, the pressure and current are then reduced slightly and the current finally shut off and the pressure increased. This process is used primarily on light materials such as aluminum. The purpose of the final pressure is to forge the weld and the resultant welds are said to be sound and of high quality.

The use of tube controlled timing for spot welding is not extensive at the present time. The proposed program on air craft, railway and duraluminum auto bodies has brought about a need for accurate spot welding control and at the present time extensive interest is being shown in this type of equipment.

GAS WELDING AND CUTTING

Gas welding and cutting is used as extensively in Europe as it is in the United States. The quality of work is also of the highest grade.

There seems to be a great interest in trying to reduce cutting costs. A great deal of coal gas is used in place of acetylene and hydrogen is seldom used. A new product known as Pyrogas has recently been introduced from which excellent results are claimed. This material is bottled as a liquid and vaporizes at a constant pressure of 100 lbs./sq. in. The gas produces a flame temperature 300 degrees F. lower than acetylene and it is claimed that one 1500 cu. ft. cylinder is equivalent to 7 cylinders of acetylene.



AMERICAN TRENDS

The applications of welding in Europe and America are quite similar thereby indicating that its economic and engineering advantages are recognized on both Continents. Many products, machines and structures are being fabricated at the present time but there are many large fields ahead for welding to conquer.

Welding has long been applied in the fabrication of machinery and special engineering equipment but there are still many cases where its application has been

limited. Machine tool manufacturers are beginning to become welding minded and the success of their preliminary efforts will undoubtedly create a radical change in machine tools. Manufacturers of rolling mills are still employing many castings although welding is now being applied in certain installations and the result should be improved efficiency and less expensive equipment. The flexibility of welded designs makes it economical to design and build a mill for the service conditions for which it is intended rather than adapt equipment designed for another mill simply because it will eliminate pattern costs.

The construction of such equipment as the flood control station across Turtle Creek at East Pittsburgh (Figure 9) and the 200″ telescope for Mt. Palomar are additional indications of the trend in the use of welding for miscellaneous products.

Pressure vessels, high pressure piping, and storage tanks have been fabricated by welding for many years. Welding in this field is unlimited and has already made possible the use of temperatures and pressures exceeding those permissible with riveted designs. An outstanding pressure vessel constructed by welding is the atom-smasher located at the Westinghouse Research Laboratories (Figure 10). This structure was designed for 120 lbs./sq. in. working pressure and contained $1\frac{3}{4}$″ plates welded in the vertical position. The confidence of the fabricator and purchaser of this vessel in welding is illustrated by the fact that it was proof tested with air to a pressure of 160 lbs./sq. in. No leaks were obtained.

Ships and barges have been either completely or partially constructed by welding for many years. The success of these structures is causing welding to become more common in the new ships. Welded ships are more rigid, lighter in weight and require less maintenance. The improved seaworthiness of a ship containing welding has also been definitely demonstrated by the H. M. S. Hunter which reportedly struck a mine while on patrol duties in the Mediterranian off Almerin, Spain*.

Railways are using arc, gas and spot welding extensively in the construction of new equipment. Spot welding of special alloys is also growing rapidly in the construction of modern aircraft.

Welding has been applied for the fabrication of buildings since 1926 but its growth has been limited. Bridge welding in America has been confined primarily to repair work while in Europe many all-welded bridges have been constructed.

The adoption of welding for building construction by such cities as New York and London, and the considered adoption of welding by Pittsburgh and Chicago will create a new era for welding in building construction. The U. S. Navy is also adopting welding for building construction and many other cities and organizations will follow suit. It is safe to assume that future buildings will be welded rather than riveted because of noise elimination and the savings created by the reduction of the amount of steel required to carry the same working loads.

The construction of new overhead super-highways is also another outlet for welding. Welded superstructures for such highways would be economical and reduce maintenance to a minimum.

The previous are just a few of the many applications where welding is being used or will be used in the future. As the science of engineering continues to progress welding will continue to play a more and more important part in every field.

FIGURE 9—The 150,000 pound flood control gate across Turtle Creek is of all-welded construction.

FIGURE 10—The thirty-foot diameter pear shaped atom-smasher is an example of welded pressure vessel construction.

*See H. Stanley on Damage to H. M. S. Hunter in "The Welder", Vol. X, No. 50, January 1938, page 15.

DISCUSSION

PRESENTED BY

G. A. HUGHES, Electrical Engineer, Truscon Steel Company, Youngstown, Ohio.

A. W. STEED, Superintendent of Maintenance, American Rolling Mill Company, Middletown, Ohio.

S. D. BAUMER, Welding Engineer, Bethlehem Steel Company, Johnstown, Pa.

A. E. GIBSON, President, The Wellman Engineering Company, Cleveland, Ohio.

C. H. JENNINGS, Research Engineer, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

G. A. HUGHES: About fifty-three years ago, Dr. Thompson discovered resistance welding. About the same time arc welding came into notice, but it was not until 1917, at the beginning of the World War, that welding really came into its own. At that particular time we know, of course, that the United States had entered the great war. There were one hundred seven ships in the United States from Germany. The engines had been damaged and it was thought that it would take about eighteen months or two years before those vessels could be commissioned. It was then that arc welding really came to be known as a potent factor of American industry. A great problem confronted the engineer of that time. Two million men were to be taken four thousand miles and put on the firing line. Equipment, munitions, supplies, etc., were to be delivered and you can readily see the great problem that confronted them. It was then that they turned to welding. Very little at that time was known and the word of the manufacturer of electrical equipment was considered as authority and law. The electrode used at that time was the one which had been used in acetylene welding, and the only question was to put on enough for sufficient strength for the requirement.

You all know the story. At the close of the war technical societies were formed to study this new method of fabrication, the American Welding Society and our own organization. I believe our own organization has been as potent a factor as any in the development of welding.

A. W. STEED: Mr. Jennings' paper is a very comprehensive word picture of the developments, present practice and trends of welding in Europe and in our own country. This paper contains facts not available to most of us and is a valuable addition to our engineering papers.

Most of us when listening to a paper try to apply it to the things with which we are most familiar. So a great number of those present no doubt think of welding as applied to steel plants.

Not many years ago many of the accepted welding practices of today were extremely experimental and in doubtful standing. Today, welded buildings, girders, crane end trucks, open hearth frames, shear and mill housings and all kinds of machinery are accepted as good practice. This leads to the simplification of maintenance practice, speeds up repair jobs and makes the piping of oxygen and acetylene around the plant practical at a lower cost of production.

Pipe welding attempted by only the venturesome a few years ago is today accepted as best practice, and the welder in the pipe gang is now a real necessity.

Our engineers and maintenance man are becoming more welding conscious every day and the flexibility in design of welded parts has materially changed, but improved, the design of equipment. When fabricating from welded parts selected materials suitable to the individual part requirement can be used to great advantage.

Welding and cutting in steel plants started in the service shops and the first attempt in this lead to many failures, but the development of materials, welding equipment and technique has raised the art of welding into the absolute necessity class.

Cutting and welding equipment are directly responsible for a very marked reduction in delays and costs in our steel mills, and they may truly be classed as "Maintenance Equipment Preferred".

One very noticeable result is the reduced number of spare parts carried. Instead of a large supply of parts castings in the maintenance inventory, a small supply of essential castings and a few slabs and plates for fabricating parts are necessary.

In the steel plants we have just started to use welding and with the development of automatic equipment, new types of rods, alloys, hard surfacing materials, brazing materials and the necessary trained men, the next few years will show developments that are far beyond our present comprehension.

The steel companies of the country with their large potential capacities must find a market for their surplus products if they are to prosper. New uses for steel must be developed so that our plants can run at a normal capacity and at a fair profit.

With new steel usage, welding will develop and have an ever increasing importance as the fabrication of steel and welding seems to be linked even more closely in the future than they are today.

S. D. BAUMER: In discussing Mr. Jennings' paper on European Welding and American Trends, it may rightfully be assumed that European welding in general is passing through the same type of progression as did American welding several years ago. Industry at that time cast around for new ways and methods of fabricating and renovating steel and its allied metals, not only as a stimulant to poor business, but also as an aid to faster delivery of a finer finished product at equal or better cost.

At this time a-c welding equipment was brought in to use because it was definitely found, in certain fields, to be 15 per cent to 20 per cent more economical, especially where design of parts or structures had odd contures and where a large number of corner welds were necessary. This type of equipment was also somewhat less difficult for the inexperienced

operator to handle. For instance: During the early part of 1935, when it was necessary to train 150 production welders for outside inspection work, we found that operators using a-c equipment learned much more quickly and qualified in 25 per cent less time, mainly because arc disturbances were not present with these sets. However, where portability and long leads were required, particularly on steel mill maintenance, the d-c equipment has been more satisfactory. Welding manipulators, trunions, and all manner of turning devices were put to very good use during this period, and trunions were designed to rotate a complete railroad car or underframe, so that welding could be performed in the down hand position.

Automatic machines of the wire fed type and the carbon arc both have taken their place in the field where similarity of design is possible, and have become very popular in the manufacture of large pipe and tanks of all descriptions.

Spot welding has also come into its own through the auto-motive industry, where standardization of parts is employed to the best advantage. There are, of course, many other fields where this process is being used, and I believe in time that more progress is possible with this equipment than in other branches of the welding industry.

The second point for discussion is that of electrodes, and it is interesting to note that Europe, with the possible exception of Germany, is using as large a percentage of coated electrodes as we are in this country.

If I remember correctly, both England and Belgium were among the first to contribute to the manufacture of the original protected arc electrode. At that time, however, the cost was so great that its use was almost prohibitive and was only employed on the most important work and sold somewhere in the neighborhood of 75 cents per pound, being manufactured in the small sizes and being applicable only in the down hand position.

Today, chemists and metallurgists have given us electrodes of the finest type at a reasonable price usable in all positions, and have kept pace with the ever changing and improved design of welding sets. With these improvements, I doubt whether 5 per cent of the electrodes used today are of the old, so-called bare type. This has been a credible achievement for both the machine builder and electrode manufacturer, and I am sure none of us would care to go through those days again where it was necessary to use an overdose of weld metal and to perform the operation at such a slow pace.

Our third point brings up engineering, design and inspection. In this branch of the industry, a certain amount of fear still exists. It is interesting to note in Mr. Jennings' paper where he says: "Design details are often specified by the customer and each purchaser has his own requirements which interferes with high production items". This, apparently is not only true of European practice but is also still noticeable in American design. Designers are still likely to specify welding that is far beyond the strength required in comparison with riveted construction. If as much time and thought were given to the training of capable designers as has been employed in the design of welding equipment, electrodes and the training and qualifications of operators and shop personnel, I believe it would be time and money well spent.

The fourth and last point for discussion is that of use of all types of gas for cutting and welding in the iron and steel industry. This branch has also grown to large proportions and is being put to so many varied uses that its advance has been hard to follow. With the automatic application of gas welding and machine driven cutting equipment, much has been done to aid the fabricator to produce a finer product. Flame hardening, descaling and scarfing in the conditioning of all types of semi-finished steel has turned this part of the industry upside down over night. At this time I do not think that it is so much a question at this period what gases we may employ but how we can economically use what we have. This type of tool, placed in the hands of competent men can and has become very effective, but placed at the disposal of just any ordinary workman can and does become very expensive and detrimental to the uses intended, and so here again is a place for training and instruction.

Time does not permit a more lengthy discussion of a very interesting subject although before closing, I might add one additional thought and that is, we cannot afford at any time to pass lightly over anything or any idea that may help us to further welding and cutting in the iron and steel industry.

A. E. GIBSON: I was very much interested in Mr. Jennings' paper because we have associates in England with whom we exchange engineering information, and have for many years. The works' manager of this particular company came to visit us some months ago, and spent about a month at our plant. Naturally, one of the things I was very much interested in was the welding development in his plant and in England. The story that I got from him was that they had not gone into welded mechanical equipment to anywhere near the extent we have in this country. That is the particular phase of welding in which I am interested because I think that offers us the largest possibilities for saving; that is, the elimination of patterns and the substitution of low priced material for high priced castings. I wish that Mr. Jennings had had more time to go into that phase of European welding.

I would like to say just a word about the commercial aspect of welded mechanical equipment, as I see it, and as we look at it in our plant. I am convinced of one thing and that is that we make our money in the engineering department and not in the shop. It is perfectly true that a shop can lose a possible profit if they haven't the proper tools with which to work, the proper management, and the proper skilled mechanics, but no shop can make a profit with poor engineering. We can't do that, because our competitors won't let us.

One of the things that we have found are paying big dividends in our work is eliminating welding in welded construction. In other words, we are interested, and we are striving constantly, to cut out all the welding that we possibly can in our welded designs. We have found that there is no tool in our shop that pays bigger dividends than a plate brake.

We have many weldments in which we have eliminated eighty per cent of the welding that would be required if we took a number of separate pieces and welded them together, as Mr. Jennings spoke of in European design. A couple of weeks ago we were running some reduction cases through our shop. They were eight feet long and four or five feet wide. I was interested in these gear reduction cases and borrowed a rule and measured the amount of bending that was done on them. On each one there was fifty-four feet and seven inches of bending. When one considers the comparative time of bending fifty-four feet of material against the time required, to butt-weld or double fillet weld fifty-four feet of half-inch material, one can appreciate the tremendous commercial advantage in the cost of the product.

In addition to bending, I don't think we are doing anywhere near enough gig and fixture work, and I am convinced that one doesn't need mass production to justify gigs and fixtures for aligning and holding work during welding operations. I have seen cases in our shop where we have cut the fit-up time more than seventy-five per cent by having suitable fixtures in which the work could be practically thrown into and quickly clamped so that the operator can go ahead. The advantage in that is that when the welder is sure of the rigidity of the parts he is welding (that is, of the component parts so they won't get in misalignment) he will proceed with his welding with a great deal more assurance. He can use a larger electrode and he will make greater speed. As far as production in shops is concerned, I think that this is a very definite trend in America and we are making some real progress.

The most outstanding example I have ever seen in welding design is this new rayon plant going up at Painesville, Ohio, some thirty miles east of here. I had the privilege of watching that development over the last four or five years. We did some little work on it. The main part was done by the American Bridge Company. It is, I think, the most intelligent piece of welded design I have ever seen. It consists of a series of step back frames, each about twenty feet long. There are two rows of rayon machinery each a half mile long, and on those frames the American Bridge Company are welding perhaps a hundred pre-machined press plates and are holding the alignment from one bored plate to another to within about 5/100″. The reduction in weight was in the neighborhood of thirty-five to forty per cent and the reduction in cost of the equipment was almost fifty per cent over the cast design.

Will you tell us a little about the mechanical parts, and the substitution of welded parts for castings, Mr. Jennings?

C. H. JENNINGS: I didn't have an opportunity to study that phase of welding as much as I would have liked to. I spent most of my time in a company very similar to our own, manufacturing electrical equipment. The work done at this plant was almost identical with ours. For example, cast bed plates had been replaced by welded steel constructions. In this particular plant the thing that impressed me was the use of very few angles or I-beams. Plates were bent into U-shapes in order to make bed plates. This was a case where a bending brake was used in order to save welding. I inquired why plates were used instead of rolled sections as it seemed somewhat unusual. In England it is not easy to get rolled sections in the sizes required and delivery is rather slow. As a result, plate constructions are used. On certain circuit breaker equipment castings used to be employed, but now this equipment is built from formed plates welded together. Welding produces a great saving in cost and, of course, places all of the work in the fabrication shop rather than having it sent out to a foundry. I found very few castings in use in the particular company in which I was associated. I wondered why they didn't use castings for certain things. The answer was that they couldn't get castings and when they did get them they were generally unsatisfactory.

I didn't have an opportunity to see more equipment of the type to which Mr. Gibson refers so I don't know just how that is being taken care of. I do know that welding is breaking into the field of mechanical parts quite extensively and I also know that industries there cannot survive any more than they can here unless changes are made to use welded construction. This fact is appreciated and the companies that aren't welding a great deal at the present time are now beginning to think of welding and are starting to buy welding equipment.

There was one point I did notice in some plants which was discouraging to me. This point reflects the conditions in America, let me say, about ten years ago, and deals with the drawing room practice employed on welded products. I refer to the practice of making drawings without locating the welds, then turning the drawings over to the shop and letting the welding operator figure the amount and location of the welding. The engineer then looks it over and puts the welding information on the drawings so that he knows what to do for the next job. I consider this one of the worst conditions and worst faults of welding, and there is a very definite reason for it. Many companies have suddenly realized that they have to go to welding. Their engineers are not familiar with welding and they don't know what to do with it, consequently they take the easy way out. They give a job to the welder and let him worry about it, instead of doing it the logical way, as we do, by training our engineers and draftsmen in welding design. I think it is absolutely wrong to expect a welder who knows nothing about the service conditions and loads to be the goat in deciding where to put the welding and how much to put on.

I also want to leave one other comment with you, and that is, "Don't forget that welding was more or less invented or discovered in Europe and not in the United States". Arc welding was discovered in Europe, spot welding in America, gas and thermit welding in Europe. The only reason the Europeans are probably not as advanced as we are is because of our good fortune in having in America plenty of raw materials, large volume production, and, as the Englishman says, "Lots of money". I think America is fortunate in having this combination of conditions and in being able to put them to work and develop the art much more rapidly than the other countries.

Although we might be ahead in America in many things, don't feel that they are behind in every case, because I have seen welding jobs there that are unequaled in this country. I will say, however, that the higher production in this country, the higher standard of living, and wage scale, and the lower materials cost has made it possible for us to spend more time, money, and effort in trying to develop high speed or high production welding methods as, for example, the union melt process, which I think Dr. Doan will speak about a little later, and our high speed spot welding. These processes have been made possible in this country and we have developed them to where they are today, but I think you will find that in the future they will be used in Europe as extensively as they are in America.

MEMBER: How about the X-raying?

C. H. JENNINGS: I found the X-ray used in only one company that I visited and that was in England. This company used its X-ray machine for the inspection of welds on pressure vessels. This particular company was, I think, one of the oldest companies in the pressure vessel business in England. I would also say that they were probably one of the most progressive. They had automatic welding equipment and they were, I think, the first in England to adopt the more recent developments in our high speed electric automatic equipment. One doesn't see nearly as many X-ray machines in Europe as in this country.

DISCUSSION

Modern COKE OVEN DESIGN *and* PRACTICE

Continued from page 53

hour or so, then stepped up to get back on regular schedule. There are investigators seeking for correlation of coke plant operation and blast furnace result who, at times, try to prove that certain furnace results are due to irregularities in oven operation of so inconsequential a nature that the claim appears to be ludicrous. Seeking correlation between cause and effect has so far been very elusive and probably will be so far for a long time to come, but it is a very important subject, worthy of close study by both blast furnace and coke plant men, and being very much interested in that subject of research, I have ventured to speak of this in the hope that some one present might have dependable facts he is willing to disclose.

In conclusion, I would like for Mr. Denig to answer two questions:

1. On Page 4. You state that the coke normally pushed is at an average temperature of 1750 to 2200°. Is this the actual temperature of the coke, and if so, how was temperature taken?

2. On Page 6. You state that it is always assumed that the builder installs the best silica brick. What is the comparison of life on fine and coarse ground silica brick?

FRED DENIG: Answering Mr. R. W. Campbell, Superintendent Coke Plant, Jones and Laughlin Steel Corporation, Pittsburgh, Pa., I wish to state:

First—With proper operation of the coke ovens the temperature difference between the waste gases entering the cross-over flues and leaving them is practically nil, and it is, therefore, evident that the effect of passing the gas through the cross-overs can be of no consequence in respect to the temperature of the gases in the top of the ovens and to the resultant by-products. As a matter of fact we have found generally higher light oil yields from coals coked in Becker ovens as compared with Koppers ovens operating under identical conditions in respect to the coal which is due to the more uniform heating from top to bottom and end to end of the Becker ovens during the entire coking process.

Second—In the Becker type underjet ovens all differentials are so low that there is positively no leak of gas. We, of course, would not recommend underjet ovens to be built had we not eliminated the high differentials.

Third—It is true that the Wilputte ovens at Gary had the so-called high and low burner in alternating flues in the heating walls, however, when building the additional Wilputte ovens the Gary people, based on their experience with the high and low burner arrangement, discarded this system and provided for burners in the Wilputte battery similar to those in the Becker underjet ovens at Gary, which burners are placed in all flues at the same elevation.

Answering Mr. E. G. Gardner, Superintendent Coke Plant, Inland Steel Company, I wish to state:

First—That the coke temperatures mentioned are the actual temperatures of the coke taken at the face of the coke cake while pushed out of the ovens.

Second—We have found very little difference between fine and so called coarse ground silica brick. There is really not so very much difference between the grind of what is called fine and coarse as is usually assumed. I am sure that other factors in the operation of a coke plant effect the life of an oven battery much more than the relatively small difference in grind of silica.

D. C. *Crane* EQUIPMENT *for* MODERN STEEL MILL *Cranes*

By J. A. JACKSON, Industrial Dept.

GENERAL ELECTRIC CO.

SCHENECTADY, N. Y.

Presented before the A. I. & S. E. Birmingham District Section February 28, 1938

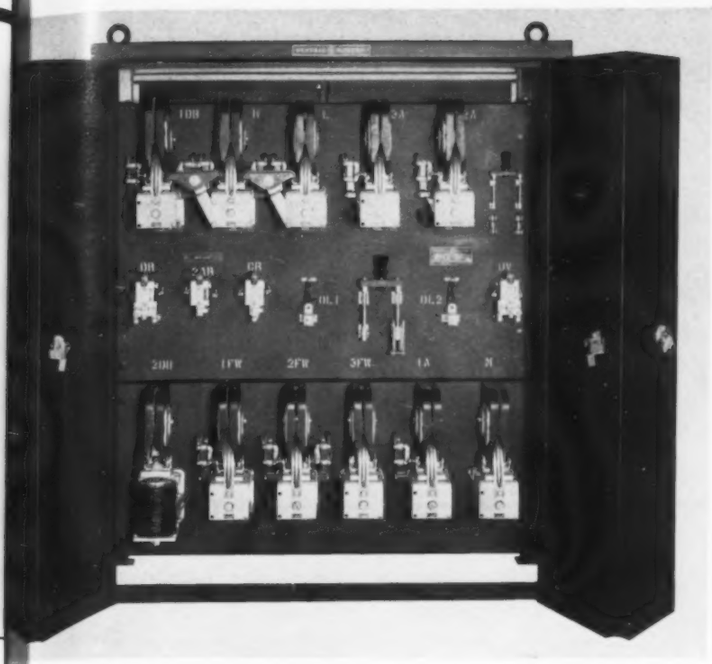
▲ IN recent years many changes in crane design and operating practice have been generally adopted which affect the size and design of the electrical equipment for steel mill cranes. Some of the more important are the use of roller bearings, tapered track wheels, high efficiency totally enclosed oil immersed gearing, high efficiency worm gears, increased speeds, two brakes on every hoist motion and power limit switches on all hoist motions. Some of these changes affect the motors and gearing as well as the control and reference will be made to this where such is the case. Also, as magnetic control is now so generally used on steel mill cranes, manual control will not be discussed. This paper will be confined to the three common motions of overhead traveling cranes, as time will not permit taking up the stripper, soaking pit, charging and other cranes with special motions for special applications.

TROLLEY MOTION

This is the simplest motion to electrify as its speed is relatively low due to limited length of travel; trolley wheel span is short, reducing to a minimum wheel flange friction due to misalignment; track conditions are good and are easily maintained in that condition and power requirements are relatively small. Roller bearings have, moreover, reduced friction losses, particularly static friction, to such low values that torque requirements for inching are much reduced. This reduction may be obtained either by the use of smaller motors with the same gear ratio as used on sleeve bearing trolleys or with the same motors and gear ratios as used with sleeve bearing trolleys, but with increased resistance on point 1 of the master to reduce the current. In adopting the first suggestion, care must be taken not to use motors too small to accelerate quickly, thereby making the trolley sluggish during acceleration. If permissible, the use of a larger gear ratio with the smaller motor will keep the rate of acceleration substantially the same as obtained from the larger motor, but with some sacrifice in maximum obtainable speed of the trolley. Acceleration rate is, after all, the important thing on a trolley motion, as length of runs are frequently not long enough to obtain maximum speed, consequently a high acceleration rate saves time. On the other hand, a high rate at the instant of starting will put too much swing in the hook. The ideal condition is met by a uniform change in the rate of acceleration. The motor torque when first applied should be just enough to break static friction and start the trolley at a very low rate of acceleration. This rate should increase uniformly (preferably along a parabolic speed-time curve) reaching a maximum when the last accelerating contactor closes after which the rate will decrease to zero as the motor accelerates to constant speed along its own speed-torque curve. This produces minimum swing of the hook load. The very small difference between static friction and running friction in roller bearings permits a much closer approach to this ideal accelerating condition than can be obtained with sleeve bearings. The torque necessary to break static friction with sleeve bearings may cause too high an initial rate after the static is broken, as sleeve bearing static friction is much higher than running friction.

High efficiency gearing also aids in solving this problem. Modern oil immersed, fine pitch herring-bone or spiral cut gearing is a desirable refinement from the standpoint of smooth and accurate operation. There is still room for study in selecting the best size of motors and the correct gear ratio for trolley motions.

Trolley control usually consists of straight reversible control with time acceleration relays and resistors to permit safe plugging. Correct resistor layout and setting of timing relays can do a lot to attain the best acceleration and jogging on a roller bearing trolley. This must be a field adjustment after installation as



Crane hoist magnetic control panel with two creeping speed points hoisting, and dynamic braking with automatic deceleration lowering. 110 hp. capacity, 230 v., d.c.

factory adjustments can not be depended on to suit all weights, speeds and varying friction of trolley motions.

There is now a decided tendency to put low torque solenoid brakes on trolley motors to serve a triple function: 1st, to retard the trolley to rest instead of using plugging; 2nd, to prevent a swinging load from moving the trolley backward and forward on the track; 3rd, to prevent coasting due to crane deflection when picking up very heavy loads. It is doubtful whether such coasting has ever happened but it has been given as a partial reason for brakes on a roller bearing trolley. However, even with a solenoid brake, it is still the practice of most operators to use plugging for retarding trolleys to rest, thereby keeping down wear on the solenoid brake. The brake is then in better condition when a power failure or some emergency causes it to be depended on to do all retarding. Plugging relays and resistors are almost universally included on trolley panels, even if solenoid brakes are used.

BRIDGE MOTION

The control of a bridge motion like the trolley control is relatively simple but much can be said on the best way to motor and gear this motion. It is quite common to find the maximum free running speed of a bridge with a modern low friction drive and tapered track wheels to be from 150 per cent to 225 per cent of the speed as specified by the crane user in his purchase specifications. If, therefore, the user's crane runway supports and bumpers were designed for the specified speed only, they will at times be subjected to shocks increased as the square of the increased speed or from 2.25 to 5 times as great. Also, if retarded from maximum speed to rest in the same length of time as from the user's specified speed, the plugging resistor or the mechanical brake must absorb an amount of energy 2.25 to 5 times as great. If designed to do this—all right—but if not, trouble is likely to be ahead. The causes for these high maximum speeds may be summed up as—1st, over-motoring; 2nd, under-gearing; 3rd, lack of a uniform method of figuring motor sizes and gear ratios for bridge motors; 4th, the practice (occasionally used) of specifying a slower speed than desired to meet production in the expectation that the usual overspeed will provide about what is desired.

These four causes justify a paper by themselves, so comments in this paper must be brief. As to over-motoring, this is at least due in part to the ultra conservatism of mill operators, (an excellent fault if not overdone) when they specify the size of motors they want on bridge motions. After all it seems that what the mill operator really is trying to get is ample torque at the track wheel treads to get a smooth and correct rate of acceleration, ample torque at the wheel treads to overcome emergencies such as bad skewing (this is not the bugbear it used to be when flat wheel treads were used) and, in case of two-motor drives, ample torque at the wheel treads to operate the crane with one motor when necessary. Notice that torque is referred to at the wheel treads. That is where the gear ratio comes in. For example, the addition of an extra 1.5 to 1 gear ratio on a given bridge drive would provide exactly the same torque at the wheel treads with a motor of similar design and speed but only two thirds the size. The rate of acceleration would not be changed while accelerating on the rheostat as it is a function of torque at the wheel treads. After the rheostat is cut out the average rate would be somewhat decreased, but the free running speed would not climb so far up the motor speed curve, giving a final maximum speed closer to that specified. The small motor would deliver as large an excess of torque at the wheel treads for emergencies as did the larger motor. It is admitted that a change in motor size and gear ratio as suggested involve other problems, but it appears that they can all be solved successfully.

There seems to be no uniform method of figuring the bridge drive motor sizes or gear ratios, either among the crane builders or the mill engineers and there is little test data on which to base a uniform method. Motors and gear ratios as used on sleeve bearing open spur gear drives have been duplicated in some cases on modern low friction drives on cranes of the same weight and span, and trouble from overspeeding and excessive speeds with difficulty in stopping has resulted. This has required the addition of more control equipment and resistors to cure something that could have been better cured originally in the motor and gearing. Adding control seldom helps maintenance. It would seem that this determination of motor size and gearing for bridge and trolley motions might be a good subject for investigation by the A. I. & S. E. Crane Committee.

The fourth mentioned cause of specifying a slower speed than desired for production with the expectation

of getting a higher speed seems to be both illogical and a gamble, and as such, should not be resorted to.

Bridge control has been modified to meet these higher (and often unexpected) speeds by increasing the plugging resistance and occasionally by connecting a relatively high resistance shunt across the motor armature on the last two points of the master. This draws more field current through the motor field and acts like a compound winding in slowing down the speed. It wastes current, causes more motor heating and complicates the control and could be eliminated by the use of smaller motors and higher gear ratios.

Maximum rate of acceleration, which occurs while cutting out the starting resistance, is a function of crane weight rather than crane friction; hence, little or no change has been required in the accelerating resistor or the setting of the timing relays on low friction cranes.

HOIST MOTION

On this motion, the correct motor size is quite simple to obtain and there is little evidence of hoists being incorrectly motored. Gearing, generally speaking, gives a speed quite close to specified full load hook speed. The control, however, steps into the lime light, as upon it (including the brake) depends almost entirely whether the hoist motion will operate as required.

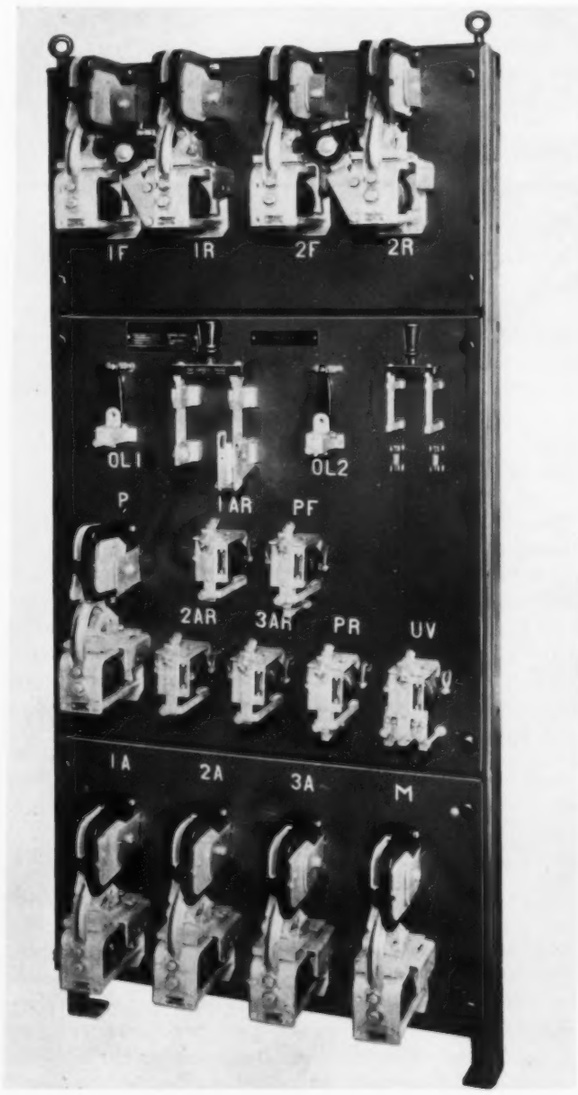
The duty on the hoist motor varies between a heavy overload as a motor when hoisting to a heavy overload as a braking generator when lowering. At this place, it might be well to point out the limitations of the hoist motion as determined solely by motor limitations which are not subject to correction by any change in the design or adjustment of the control or resistor. First the light hook hoisting speed is dependent on motor characteristics, the size of motor selected and the gear ratio used. Over-motoring and too small a gear ratio increase the light hook speed hoisting, making it more apt to run into the hook limit before the operator can stop it. The light hook speeds of roller bearing hoists frequently reach 300 per cent of full load hook speed and even higher speeds have been measured. This is 20 per cent or more higher than speeds of sleeve bearing cranes. Stored energy in the rotating parts is a function of the speed squared; hence, coasting distance during dynamic braking from limit switch operation plus solenoid brake torque varies as the square of the speed existing at the instant of tripping the limit switch. For example, if the light load speed is 20 per cent greater than on a sleeve bearing crane when the limit switch sets, the coasting distance will be increased by 44 per cent ($1.20^2 = 1.44$) if the braking adjustments are set for a light hook speed as obtained with sleeve bearings. This may be sufficient to unshackle the rope and drop the hook block.

In the lowering direction another limitation enters which is dependent on magnetic conditions in the motor. This limitation is in maximum lowering speed. The series motor, as connected with all hoist control schemes, becomes a shunt motor or generator (depending on the hook load) operating with a weakened field of constant current strength on the last point of the controller.

Referring to Figure 1 showing the connections used on the last lowering point of most hoist controls, it is seen that the motor field is connected across the line in series with a current limiting resistor RF. The higher this resistance, the weaker the field flux and the higher the speed of the armature.

Mill motors are designed specifically to operate as series or compound motors and they rebel against being operated as a weakended field shunt motor or generator at heavy torque loads. When lowering rated crane load, the dynamic braking torque required equals the hoisting torque times the square of the mechanical efficiency of the crane. With an 85 per cent efficient crane the dynamic braking torque required to lower rated load is 72 per cent ($.85^2 = .72$) of the torque required to hoist that load. Now remember that torque is proportional to armature current times flux and flux is a function of field current. To obtain a high lowering speed, a weak field with corresponding reduction in flux is essential; hence, to produce a given amount of torque, the armature current must go up as the flux

Reversing plugging control panel for crane bridge or trolley duty, 25 hp. capacity at 230 v., d.c.



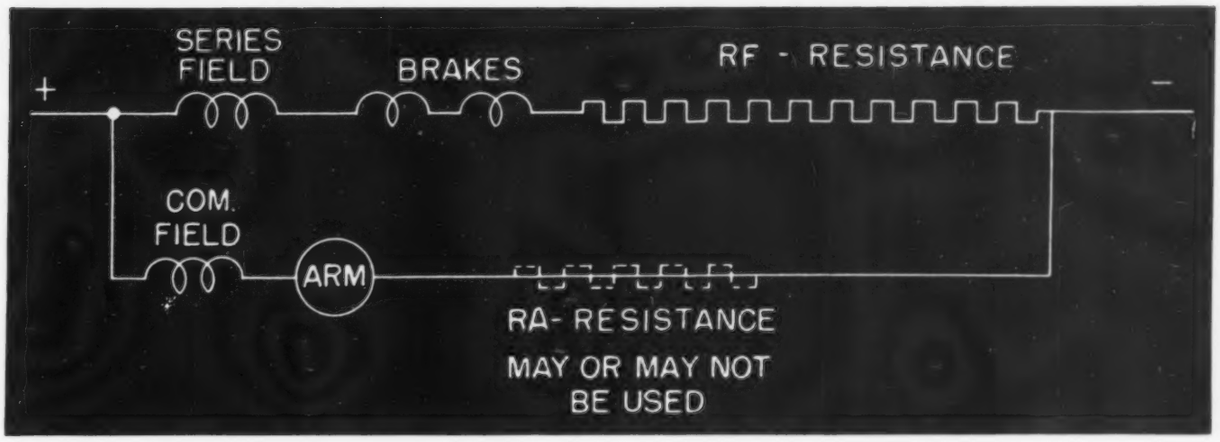
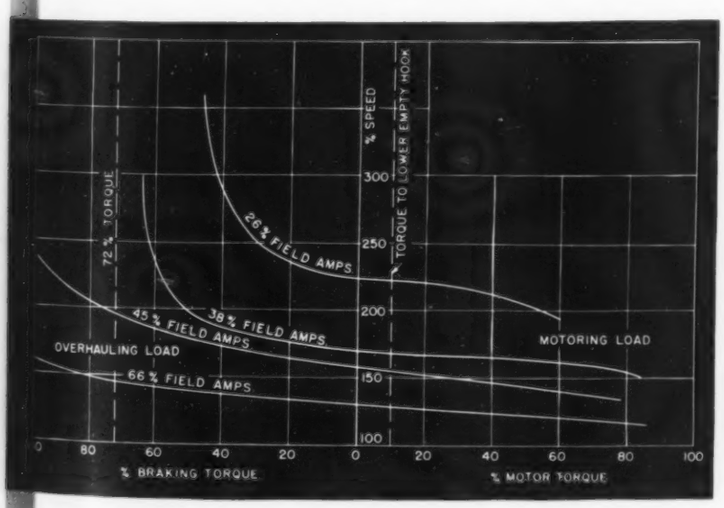


FIGURE 1—Schematic diagram of last point lowering on crane hoist control equipment.

comes down. To produce 72 per cent dynamic braking torque with the weak field necessary to obtain the high speed will usually require more than full load current in the armature. This increased armature current increases the armature reaction which further reduces the effective main field flux and this, in turn, calls for more armature current to supply the torque. Thus the vicious circle is started. A point is reached for some torque requirement where the armature reaction reduces the effective field flux to an extent which causes a dangerous speed increase unless the master switch is moved quickly towards the off point.

The curves in Figure 2 show the relation between speed and torque for a typical mill type series motor operating with a weakened field as a shunt motor or generator. The percent amperes in the field circuit as given on the curves is the percent of the ½ hour rated current of the motor operating as a series motor and the curves were plotted from actual test data. The interesting part is the shape of the curves when lowering a load. Remembering that an 85 per cent mechanical efficiency crane takes 72 per cent as much torque to lower a load as it does to hoist that load, it can be seen that the motor will not produce 72 per cent torque with either 26 per cent or 38 per cent field current and a runaway condition would exist if attempted. The light hook lowering speed with 38 per cent field current is approximately 170 per cent of full load hoisting speed. Curves are also shown for 45 per cent and 65 per cent field current which show that to secure a stable speed at 72 per cent torque, light hook speed can not be much over 150 per cent. A 45 per cent field strength might not be safe if loads greater than rated load are to be handled on the last point lower. These curves were taken on a specific commutating pole motor, and while other motors might show better stability, some might show worse.

FIGURE 2—Speed-torque curves of mill type series motor, operating as a shunt motor with weakened field.



No adjustment of control except a permanent strengthening of field current with resultant speed decrease will overcome this trouble. Commutation also becomes bad under this high speed unstable condition, thereby increasing maintenance. The use of a step-back relay (sometimes referred to as a high speed relay) is resorted to on some hoist controls which permits high speed with light loads but prevents high speeds with resultant danger when handling heavy loads. This relay operates as a function of armature dynamic braking current and strengthens the field current when the armature current approaches too high a value. A complicated differential relay is required for this purpose. Its operation causes an abrupt speed change when lowering heavy loads with no simultaneous master switch movement and this has been known to confuse crane operators. Its failure to operate leaves a dangerous circuit set up with no protection but the operator's good judgment.

With these inherent limitations in mind, the desirable characteristics of hoist control can now be enumerated. Its most essential characteristic is that it shall provide either power or dynamic braking on all lowering points, depending on the requirements of the load without the use of either judgment or movement on the part of the crane operator and without the operation of any device on the panel when the requirements change from power

to dynamic braking or vice versa. This characteristic must be inherent in the circuit.

Referring to Figure 3 which shows the fundamental schematic power circuit on which all hoist controls are based, it will be seen that the current through the series field (SF), brakes (B), and resistors (RF and RL) flows from + to — or from left to right. A current also flows through the armature (ARM), commutating field (CF), and limiting resistance (RA) from + to —, or from left to right as shown by arrows marked M. These currents produce a driving or motoring torque rotating the armature in a direction to move the crane hook downward. The rotation sets up a counter electromotive force in the armature opposing the flow of the armature current. With no load on the hook, a stable speed condition is soon reached where the torque produced just equals that required to overcome all crane friction and keep the hook lowering at constant

There are many types of cranes from the ultra safe ladle crane, or the accurate roll changing crane, to the rough duty skull cracker crane. A hoist control with sufficient built-in flexibility of adjustment to be satisfactory for any crane is an advantage particularly to maintenance men. Such a control needs to be designed so that as far as possible, adjustments affecting lowering are independent of adjustments for hoisting and vice versa. When lowering adjustments affect hoisting or vice versa, a compromise adjustment must be accepted and best results are not obtained.

For refined work, accurate jogging, particularly in lowering, is essential. On modern high efficiency, high speed cranes, it becomes preferable to use a different arrangement of circuits and resistors on point 1 lower than were used on low efficiency cranes, to obtain correct jogging characteristics and the required slow lowering speeds. Also, the use of two brakes changes the

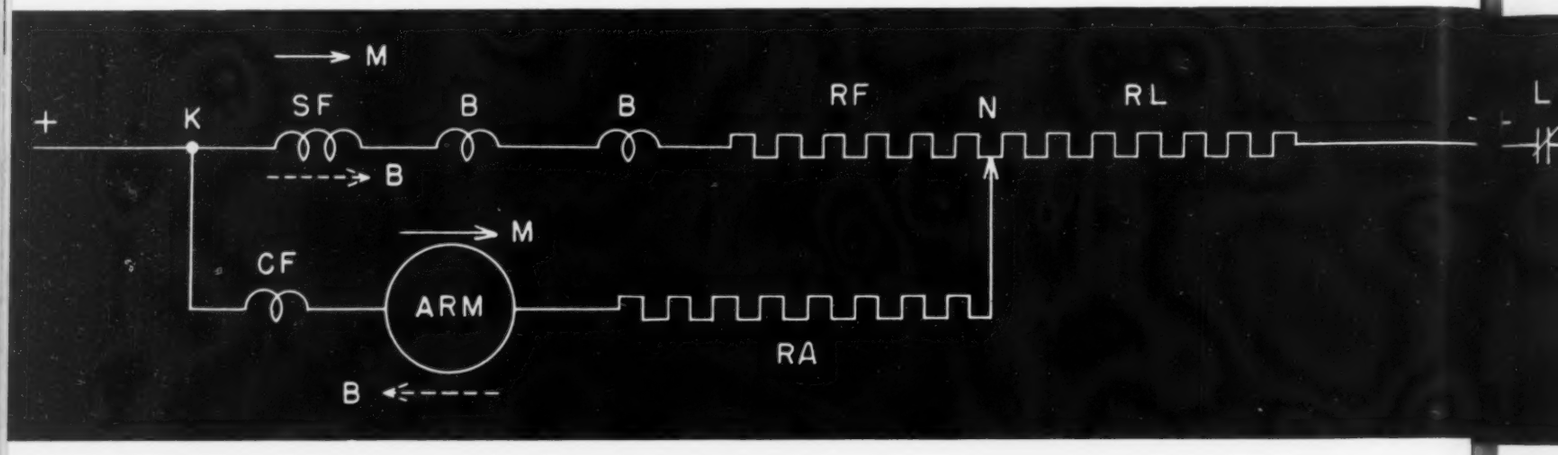


FIGURE 3—The fundamental schematic power circuit, on which all hoist controls are based, provides dynamic braking.

speed. If, however, there is a load on the hook which, due to the effect of gravity, will overhaul the armature and speed it up, the cemf will increase and the armature current decrease until the cemf becomes exactly equal to the volts drop between K and N in the series field circuit. When this happens, the armature current becomes zero and torque produced is zero. The hook load, under the influence of gravity, continues to speed up the armature and, as the field is still excited, the cemf becomes greater than the volts drop across KN. This cemf, being opposed to the impressed voltage from line, reverses the armature current which now begins to flow from right to left as shown by arrows marked B. This reversed current gives reverse torque or dynamic braking. It flows through the series field, adding to the current flowing from the line, thus increasing the flux and further strengthening the braking torque. It also flows through resistors RF and RA and dissipates its energy therein in heat. When the torque generated in the armature just equals the reverse torque caused by the pull of gravity on the hook load, the speed and current become constant and the load is safely lowered. Retardation is brought about by reducing resistors RF and RA permitting more braking current to flow. This type of control circuit therefore produces automatically just the correct amount and direction of torque required by the load on the hook.

inherent resistance and inductance of the circuits and introduces a longer time constant which must not be overlooked. Accurate jogging should be obtainable on point 1 of the master switch for either light or heavy loads. It is confusing and awkward to have to jog to point 1 for one load and to point 2 or 3 for another. Thus, point 1 must provide sufficient torque to break static friction and start a light hook down but must have little beyond this as excess torque is detrimental to lowering a heavy load. The next essential is that brake show pressure should be eased off but applied again very rapidly. This may be more readily appreciated if it is known that full load hanging on a 40 foot per minute hook will drop approximately one inch in .1 second if the solenoid brake is suddenly released and with no power whatever applied to the motor. With motor torque applied as is customary, a greater movement will result. A 1″ movement is not considered good jogging control for a 40 fpm hook. Brake operation when jogging may best be visualized by likening it to automobile braking. Assume an auto standing on a steep hill and the driver being requested to move

forward exactly 1″—no more no less. How would he do it? He certainly would not release his brake as rapidly as possible and then step on it suddenly and hope to hit the mark. He would release his brake gradually until motion started and keep the car under control by maintaining some degree of braking. When the 1″ mark was almost reached, he would push his brake in as rapidly as possible to stop quickly. A hoist control can be designed to closely duplicate this action and yet the delayed action is so short as to be unnoticed when a quick getaway to full speed is required.

Figure 4 shows a schematic diagram of the power circuits to obtain brake operation and accurate jogging as just described. Designating letters have the same meaning as in Figure 3 in addition to which a resistor RB and three contactors L, 1DB and 2DB are included. In jogging to point 1 lower, contactor 2DB which is closed in the off position, remains closed and contactors L and 1DB are closed simultaneously by the master switch, no sequential interlocking being necessary. The current flowing through the series field (SF) has two paths, viz. through the highly inductive path BB and RL and through the non inductive path RB, RA, RL to line. The armature current also has two paths, viz., through the highly inductive path RB, B, B, RL and through the non-inductive path RA, RL to line. Momentarily, most of the current takes the non-inductive path but the current begins to build up in the inductive brake coils at a rate determined by the time constant of the circuit. Brake shoe pressure decreases at approximately the same rate that the current builds up, thus permitting the armature to start rotating slowly against the braking effort still applied by the shoes. This prevents the hook load from running away with the armature as happens if the brake shoes are suddenly released by forcing the total current through them. Before the brake solenoid has completely released its armature and freed the shoes from the wheel, the operator returns his master to the off point. Contactors 1DB and L drop out immediately. This opens the discharge path through RB, RA around the brake coils BB, forcing the fastest possible current decay in the brake coils with a resulting rapid application of shoe pressure. Contactor 2DB remains closed providing a dynamic braking path through the armature and field to assist in a quick stop.

A 30 ton, 40 fpm crane using this control has been repeatedly jogged by an inexperienced operator to ⅜″ with a 125 per cent load hanging on the hook.

Snappy response to the master switch is most desirable for any kind of operation. All contactors which must close to put current through the motor and produce torque should close direct from the master switch without any sequential interlocking. Such interlocking introduces an undesirable time lag which makes jogging more difficult. On the other hand, protective features frequently provided by such sequential interlocking, such as prevention of solenoid brake release until a dynamic braking circuit is established, must be provided by other means.

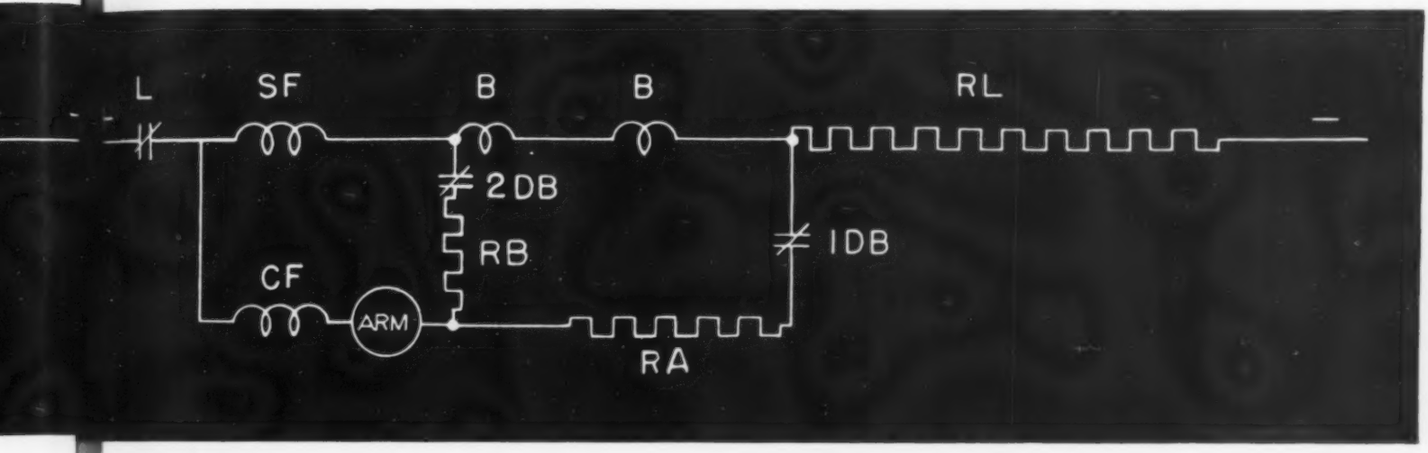


FIGURE 4—Schematic diagram of power circuit, with connections on point one lower, to obtain brake operation and accurate jogging.

Speed on the last lowering point of the master should not only be held within the limitations of the motor as described previously, but the speed regulation (difference in speed) between light hook speed and rated load speed should be a minimum. As on any shunt motor, this speed regulation is a function of armature circuit resistance, the higher this resistance the poorer the regulation. When the resistance is reduced to only that in the armature, commutating field, trolley wires and shoes and other essential wiring between the motor and controller, the regulation is the best it is possible to obtain and the full load lowering speed is the smallest percentage above the light hook lowering speed. Any extra resistance left in the armature circuit increases the spread between light hook speed and full load speed. Referring again to Figure 1, when resistance RA is omitted on the last lowering point, the best speed regulation is obtained.

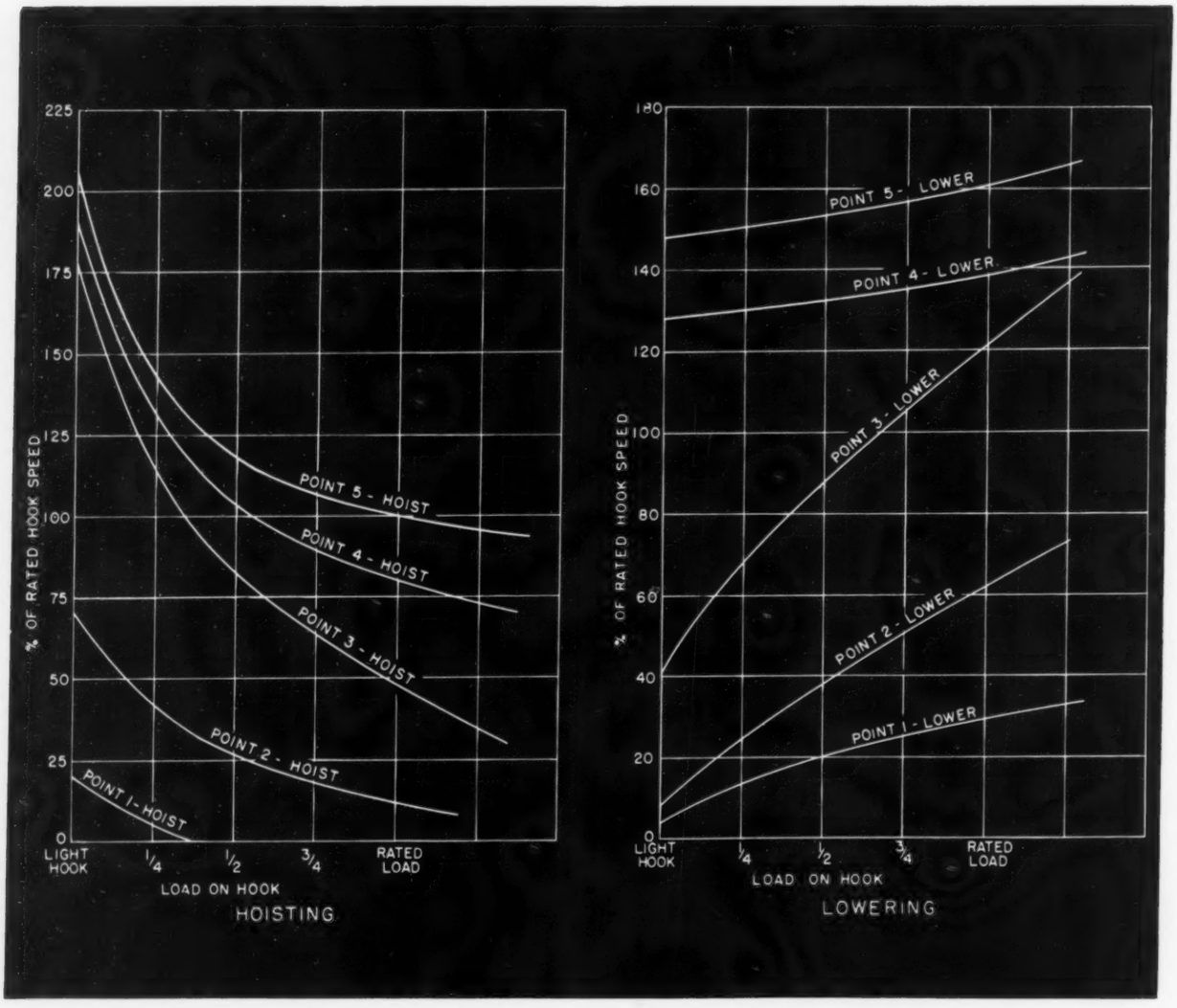
When lowering a load at the high speeds to which crane control equipments are commonly adjusted (often from 135 per cent to 160 per cent of full load hoisting speed) the stored energy in the entire moving system (armature, brake wheel, gears, drum and load) is increased as the square of the speed. Thus, at 135 per

cent speed the stored energy is 182 per cent of the stored energy when lowering the same load at 100 per cent speed and at 160 per cent speed the stored energy is 256 per cent. Obviously, if the greater part of this energy can be dissipated, when retarding to rest, as heat in resistors rather than in the brake shoes and wheel, brake life will be increased, brake maintenance decreased and the brake will be kept in better condition for emergencies should they arise. If, in accomplishing this result, current peaks through the armature can also be reduced, commutators and brushes will require less attention and gear teeth, bearings, ropes and other mechanical parts will be subjected to reduced mechanical stresses. These results can be accomplished by a magnetic time decelerating relay which, on moving the master switch back from the high speed points to the first point or to the off point, holds the solenoid brake released by dynamic braking current until the speed has been reduced to a small percentage of its maximum when the brake is permitted to set. Assuming that this reduced speed is 25 per cent of the maximum when the brake sets, there remains only 6.25 per cent of the original total stored energy to be dissipated partly in the solenoid brake wheel and linings, and partly by dynamic braking which continues to be partially effective almost to standstill. When no decelerating relays are used, more duty is placed on the solenoid brake and the motor is subjected to high commuting peaks. Where decelerating relays are used only to time in the dynamic braking contactors but not delay the solenoid brake setting, the duty on the brake is more severe.

When the decelerating relay is used to hold off the solenoid brake, there is a slight hook drift while the relay times out and dynamic braking is retarding the load. This drift time can be adjusted by changing the time setting of the relay. The relay should be so connected as to be ineffective when retarding from the

FIGURE 5—Hoisting speed load curves of a direct current crane hoist equipment with shunted motor on points 1 and 2 for obtaining stable slow speeds.

FIGURE 6—Lowering speed load curves of a direct current crane hoist equipment showing good speed regulation on points 1, 4 and 5, and good speed dissribution between controller points.



lower speed points, as speed on these points and the stored energy in the moving parts are too low to justify its use and it might interfere with accurate jogging.

Time limit acceleration, rather than current, or cemf is preferable, to prevent stalling when handling overloads.

Stable slow speeds are needed for many kinds of crane operations, both hoisting and lowering with all loads. See Figures 5 and 6. A resistor layout for point 1 lower which will jog a light hook down and will continuously lower rated crane load at 30 per cent or less speed is quite desirable. A shunted motor connection in which a resistor is connected across the armature and field is commonly used for obtaining slow stable speeds hoisting. This connection is very effective but it introduces one feature which may be considered undesirable by some operators. If the operator permits his hook to go into a limit switch while hoisting on a master switch point using the shunted motor connection and with a hook load sufficient to overhaul the motor, the load will oscillate up and down continuously in the limit switch zone until the operator returns the master to the off point. The reason for this is that when the limit switch opens, the load is brought to rest but the solenoid brake is held released by a sneak circuit through the armature shunting resistor. The load overhauls the motor and lowers until the limit switch resets when hoisting starts again and the cycle is repeated. Obviously, this is not a serious condition, as limit switch operation is normal when hoisting on the higher speed points not using the shunted motor connection. Shunted motor points are very slow speed points and the limit switch is seldom tripped when hoisting on them. There are two ways of overcoming this oscillating condition—the first is to omit the motor shunt and sacrifice speed control. Some crane duties do not require this refined speed control. Second, add a trolley wire and shoe and change connections so that the sneak circuit is broken up.

Obviously, a hoist control must contain all necessary protective features such as assurance that a dynamic braking circuit will be set up at the off point and on all lowering points; protection against short circuits by faulty contactor operation; assurance of correct contactor and relay sequencing if the master is plugged in either direction; assurance against a runaway condition by a solenoid brake release before a dynamic braking circuit has been established; overload and undervoltage protection; and any other protection which the peculiar arrangement of control circuits requires to make operation entirely safe and reliable.

DUPLEX DRIVES

Perhaps the important reason for using duplex drives on bridges and hoists is to insure operation, usually at reduced speed, if one motor fails. In order to obtain full value of this insurance, the control equipment must be designed with sufficient flexibility to permit such operation without lengthy delays. A failure in control equipment is as likely to occur and perhaps more so than in the motor; hence, to make the insurance complete, each motor should have its own individual control panel. Throwover switches can be provided to connect either motor to either control panel.

For successful operation of two motor drives the accelerating torque peaks of each motor must occur simultaneously and should be of equal magnitude. With two control panels as suggested, simultaneous contactor closing is assured by connecting the contactor coils for each step in parallel and closing the coil circuits from a single set of accelerating relays. The magnitude of the peaks can be made alike by correctly adjusting each step of the resistors.

To carry the insurance one step further, each motor panel may contain a set of accelerating relays, only one set of which is used. The spare set may be thrown into use by a two-position switch if a failure occurs in the relays normally used.

Any control scheme tieing up the control of a two-motor drive into a single panel, and particularly through a single set of contactors, defeats one of the principal features of the drive. A complete crane shutdown with such a control can result from a single contactor, relay or control circuit failure.

MECHANICAL CONSTRUCTION AND PROTECTION

From the standpoint of mechanical protection, it is becoming quite common to put steel cabinets around crane panels and there is no doubt but that in many locations the reduced maintenance and outage time justify the extra cost. Such enclosures should be practically dust-proof and strongly built to withstand vibration. Doors should take up minimum space when open and be provided with good catches and locks.

Vibration causes many crane control failures and where bad, specially designed panels have been built to withstand it. They are low in height and are provided with diagonal braces and a welded box frame to prevent weaving. This construction is likely to become more commonly used.

CONCLUSION

A crane is an expensive piece of equipment. It is not a processing machine, however, and adds no value to the material it handles. It does add overhead expense and careful study is justified to reduce this overhead expense to a minimum. Also, its operation should be made as simple, safe and efficient as possible. The use of smaller motors with larger gear ratios on bridges and trolleys will in many cases help to accomplish this result. For the hoist motion, the selection of a flexible control will aid in making the crane a better and more economical machine for its job. Such a control can be adjusted easily to best handle the required work, it will provide features to adequately protect both the mechanical and electrical equipment, and will reduce maintenance expense.

Steel Mill

POURING PIT REFRACTORIES

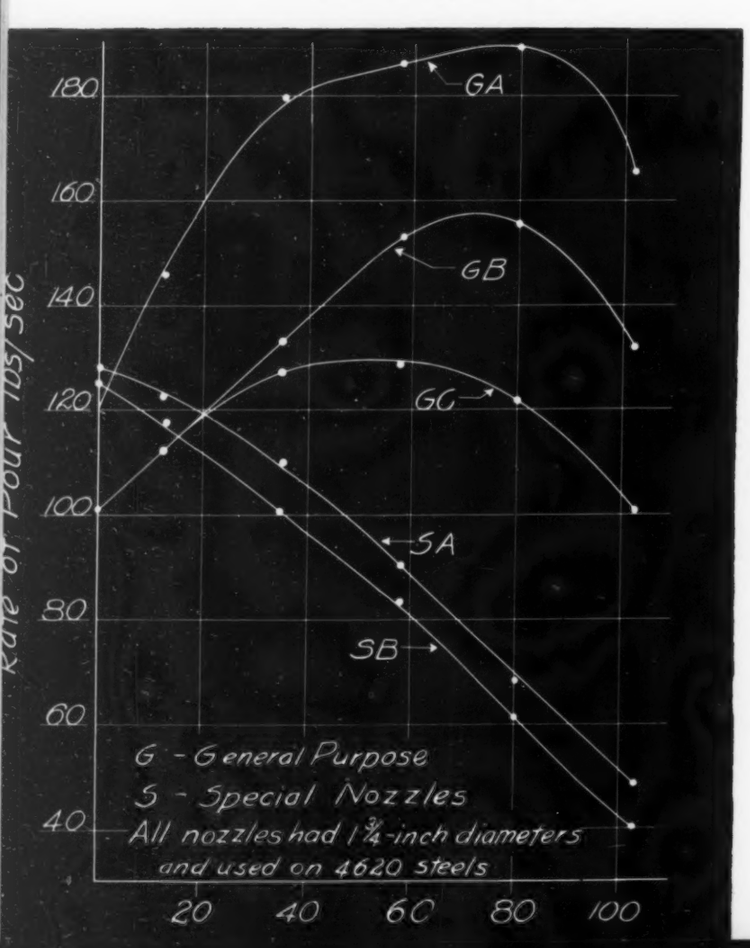
▲ ABOUT one hundred and twenty-five members and guests of the American Ceramic Society attended the recent technical session of the Refractories Division at Bedford Springs, Pa. The program consisted of a symposium on steel mill pouring pit refractories.

Dr. Walter J. Rees, of the University of Sheffield, England, vice-president of the British Ceramic Society, and past-president of the Refractories Association of Great Britain, was the guest speaker. Dr. Rees' remarks concerning the British pouring pit refractory practice were of considerable interest. He emphasized the necessity of exact manufacture of ladle brick: proper clay selection, proper grinding and mixing, and proper water proportion. Exact manufacture and de-airing is the most important point in the ultimate performance of the refractory.

Dr. Rees further emphasized the importance of permeability of the brick, rather than its porosity, as a requirement for a satisfactory ladle brick. This service calls for a dense brick, with low spalling characteristics. He stressed strongly the importance of proper setting up, with tight joints and proper joint cement, as well as thorough drying of the ladle and keeping the nozzle warm. Few magnesite nozzles are used, but many nozzles with magnesite inserts. Some work has been done with plumbago brick, which, although costly, appears to have possibilities, particularly for stopper brick, where it apparently becomes sufficiently plastic to effect a good seal. He stated that the trend in Great Britain is toward the use of higher alumina brick in runners as well as in ladles.

Abstracts of the papers read at the meeting follow.

FIGURE 1—Pouring rates as determined from actual tests on various types of nozzles.



INFLUENCE OF NOZZLES ON THE POURING RATES OF ALLOY STEEL

By E. E. CALLINAN, Comb. Engr.
E. C. HITE, Refrac. Engr.
Timken Roller Bearing Co.
CANTON, OHIO

This paper presents interesting results of work done on pouring nozzle brick.

The effects of pouring rates on steel quality may be as follows:

1. Poor ingot surface due to scabs resulting from improper pouring rates.
2. Undesirable ingot structure as caused by unsatisfactory skin thickness or pronounced segregation, which may be due to improper pouring rates.
3. Amount and distribution of inclusions entrapped in the ingot may be affected by various pouring rates.
4. Pouring rates affect mould life, which in turn affects ingot surface.
5. Pouring rates to a certain extent determine the presence of skull in the ladle and the teeming temperature of the last part of the heat.

The study of the effect of design and composition of the nozzle upon pouring rates was made on twenty-six different brands of nozzles from ten different refractory companies. The nozzles are grouped into two divisions: general purpose, with a P.C.E. of 16–27 and a porosity of 10–20 per cent, and special nozzles, with a P.C.E. of 31–37 and a porosity of 10–28 per cent.

The flow of molten steel was found to follow closely the formula:

$$\text{Lb. steel per sec.} = 3.1416\ k\ r^2\ d\ \sqrt{2\ g\ Z}$$

where k = nozzle coefficient
r = radius of vena contracta of the stream, in ft.
d = density of steel, lb. per cu. ft.
Z = head of steel on nozzle, ft.

The value of the nozzle coefficient follows closely

that used in regular flowmeter practice, running from about .62 for the usual nozzle design up to approximately 1.0 for a stream-lined nozzle.

The pouring rates obtained from tests are as shown in Figure 1. In the general purpose nozzles, the pouring rate changes considerably, due to erosion of the nozzle, with a decreasing ferro-static head. This erosion seems to follow lines so as to produce streamline flow, which raises the nozzle coefficient and increases the pouring rate. In the special nozzles, flow drops rapidly, due to an actual build-up in the nozzle together with the decreasing head. Figure 2 shows general and special purpose nozzles before and after use.

Original orifice design in general purpose nozzles has small effect in controlling pouring rates because of the erosion to a streamline design. By providing an original streamlined nozzle, it would be possible to teem the first part of the heat at a higher pouring rate with the same size nozzle. The objectionable feature of the general purpose nozzle is its excessive erosion.

In the special purpose nozzle, the original contour is maintained, and is therefore important in control of pouring rate through the entire period of teeming. It is believed that a streamlined design will reduce the build-up on the tip of the special purpose nozzle, which should provide a more desirable type of stream, but with a volume still a parabolic function of the nozzle area and the ferro-static head, which is not very desirable.

The ideal pouring rate is generally believed to be one which will be uniform through the entire teeming period. The velocity of the metal stream at the vena contracta varies as the square root of the head of steel in the ladle, which decreases during teeming. To maintain a uniform rate of pouring, the vena contracta must increase as the head decreases. Therefore the nozzle should be between the two types mentioned here, so that it will erode only enough to compensate for the decreased head. It should have a modified streamline orifice. It is expected that more work will be done to determine the final design of nozzle, which will depend on the effects produced by differences in thermal conductivity, porosity, grain size, and general workmanship.

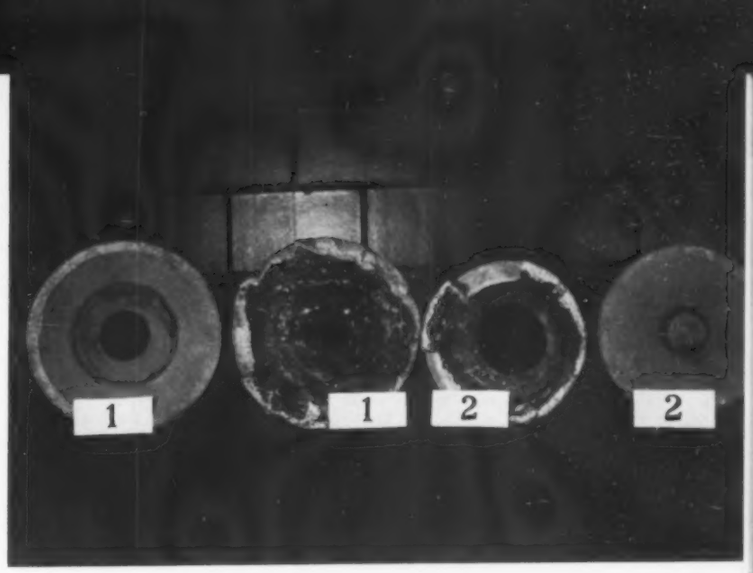


FIGURE 2—Photographs of pouring nozzles, before and after use. No. 1 is a special purpose nozzle, No. 2 a general purpose nozzle.

POURING REFRACTORIES AS A SOURCE OF NON-METALLIC INCLUSIONS

By D. L. McBRIDE, Research Engr.
BETHLEHEM STEEL CO.
JOHNSTOWN, PA.

▲ THE improvement of steel quality calls for the reduction of inclusions, the sources of which are numerous and difficult of determination. Bad pouring practice is an important contributory source of both surface and internal seams.

The tapping spout must withstand heavy impact and high velocity of the metal. Spout erosion is serious and will give inclusion. Spout linings of magnesite or chrome-magnesite have been tried, but has not yet proven its worth, nor will it guarantee freedom from non-metallic inclusions.

Ladle refractories must withstand high temperatures and chemical attack by the steel. Tests have shown that silica brick is attacked, and clay refractories with considerable fluxing materials even more severely so. Ladle erosion amounts to ½ to ¾ of a brick (3.5–5.5 lb.) per ton of steel. If it all enters the mould, it would amount to .015–.023 per cent by weight of non-metallic inclusions.

Sleeve brick requirements are even more severe, as it must protect the stopper rod to prevent leaky stoppers. The ideal sleeve brick should have high resistance to thermal shock and to slag and metal attack, with low thermal conductivity. The development of the clay sleeve to withstand the action of slag and metal, while holding its other properties, is needed.

Inferior pouring nozzles, with excessive or non-uniform erosion, result in erratic performance, with canted or spraying streams and cause internal and surface seams. Tests on eighteen heats showed these faults to give four times as many seams as with good pouring practice.

While there are other sources, pouring pit practice and pouring pit refractories can be an important source of inclusions. The use of denser, hard-burned clay brick of high refractoriness, or the development of a refractory not attacked by slag or metal would do much to eliminate pit refractories as a source of non-metallic inclusions.

REFRACTORIES FOR BOTTOM POURING

By W. C. KITTO, Supt. O. H.
PITTSBURGH STEEL CO.
PITTSBURGH, PA.

▲ THIS paper deals with bottom pouring of round ingots of dead killed steel. Heats of 125–130 gross tons of .10–.50 per cent carbon steel are poured into ingots weighing 1250 lb. to 5500 lb. Ten to eighteen groups of ingots are poured per heat.

Refractories for this service must withstand high temperatures and severe erosion of the metal stream. Magnesite nozzles, 13½″ long, with bores of 1⅜″, 1½″ or 1⅝″, are used, with graphite stopper heads. Teeming temperatures run about 2900 degrees F., so that no skull is left in the ladle. This temperature must be closely watched, as too high a pouring temperature may result in cracked ingots. Pouring is effected as fast as possible. Regardless of ingot size, pouring rate is such, and the number of ingots per group is so regulated, that the volume per minute and the rise in the moulds is the same. Hot steel, poured too slow, will have brick inclusions.

The center runner is 2⅜″ inside diameter and 5¼″ outside diameter. All other runners have 1½″ bores, with 1½″ outlets.

Analysis of the dead burned magnesite nozzle is as follows:

SiO_2	3.10%
Fe_2O_3	7.44%
MnO	None
Al_2O_3	2.59%
CaO	5.70%
Cr_2O_3	.77%
MgO	80.40%

The bell in the nozzle is shallow, and saucer shaped.

Good hollow runner brick for bottom casting may run as follows:

	No. 1	No. 2	No. 3
SiO_2	51.30	56.90	55.92
Fe_2O_3	2.43	3 72	3.71
Al_2O_3	43.57	35.58	38.59
CaO	.25	.30	.60
MgO	.10	.15	.50
TiO_2	2.30	3.00	.....
Porosity	16.59	10.59	.....
Alkalies	.....	.....	.48

Runner brick must be burned hard enough to have a glazed surface. They must be free from warpage and cracking, and the hole must be smooth and straight. Runner brick is subjected to a test, in which a 9″ length of brick, on end in a furnace, is raised to 2600 degrees F. with an imposed load of 25 lb. per sq. in. If there is no deformation, the brick is considered satisfactory. Runner brick which will withstand this test is safe to use regardless of chemical analysis.

Well fitting and tight joints are necessary, and setting should be carefully done. Plates must be well cast and carefully cleaned after each pour. Too high a teeming temperature may cause breakouts. Proper teeming temperature is important, and may eliminate much trouble.

A MEMOIR ABOUT STEEL POURING REFRACTORIES

By C. L. KINNEY, Refrac. Engr.
CARNEGIE-ILLINOIS STEEL CO.
SOUTH WORKS, CHICAGO, ILL.

▲ THE memoir deals with the steel pouring refractories as used in the manufacture of basic open hearth ingots. Attention is directed to the growth of and improvement in this process, and the premise made that steel pouring refractories have not developed concordantly.

The percentages of fire-clay eroded per ton of ingots is estimated, and it is submitted that more of this turns out to be inclusions in steel products than is generally conjectured.

Nozzle brick are discussed and the kinds of failure and the consequences are illustrated. The uses of low and high softening temperature fire-clay brick linings for steel pouring ladles; and the relation of each type to ladle lining costs, inclusion occurrence and the allied steel conditioning costs, are discussed.

Marked "bloating" which occurs in the best of the low softening temperature ladle-brick is held to be important insofar as longer ladle lining service is concerned.

High softening temperature steel ladle brick might be expected to erode less than low softening temperature; that thereby the probability of inclusion occurrence would decrease and that ladle service would increase. These expectations are fulfilled only in part, because of brick joint erosion, spalling and cracking; all of which are illustrated. Laying this type of brick with a variety of high-temperature cements did not markedly reduce brick joint failures.

A composite ladle lining of high and low softening temperature brick is considered, as is its nominal excess cost per ton of ingots, and the relation of this cost to steel conditioning cost.

Tom M. Girdler ADDRESSES BANQUET *of* A. I. & S. E.

▲ WE have traveled a long distance in the steel industry since that day more than half a century ago when Captain Bill Jones, one of the great steel masters of his time, declared that chemistry would ultimately bring the business to ruin.

Were Captain Jones living today and could he have seen the amazing engineering exhibits at your exposition and heard of other wonderful engineering developments as described by the able engineers on your program, he would have been the first to admit the error of his prognostication. He would know now, as we all know, that without chemistry and its allied activities of research and engineering, steel could never have achieved its modern miracles.

Foremost steel mill engineering group in the world.

What we have seen and heard here this week may well make those of us in steel a little more proud of our industry and a little more certain that the membership of this Association as a body stands as the foremost authority on iron and steel engineering problems in the whole world.

In the steel industry we are engaged in the progressive solution of the various problems of steel making. We are working to see how new steels can be made to fit new uses; how the uses of old steels can be extended; how standard steels can be produced more cheaply; how steel can be made more universally adaptable to all the various wants of mankind through greater efficiency in production methods. In a word, we are constantly striving to increase the service of steel to mankind.

I wonder if even we in the industry, intent upon our day-to-day tasks, always recall the great advances in steel and the vast contribution it already has made to civilization. From the days it provided the material for the steel plow-share, for the steel reaper and for the steel rail, the eyes of the industry have been always forward and its efforts ever bent upon anticipating the expanding needs of man.

Industry has spent huge sums in research and maintenance in last decade.

Each decade has brought new and ever widening horizons for steel. Even in the decade of depression, through which we have been passing, the industry has spent nearly $100,000,000 on research and at least $1,000,000,000 in modernizing its plant equipment. I believe those were wise and necessary expenditures. There are many reasons to believe that in the next decade steel has ahead of it a period of greatly expanded activity and demand. The industry even in lean times has been keeping itself fit for all possible requirements the nation may place upon it.

The modern steel industry was ushered in some 70 years ago with the invention of the Bessemer process. That historic development was followed by an unending succession of advancements, touching nearly every department of steel making.

The open hearth process, blast furnace refinements, electrification of steel plants, the substitution of laboratory control methods of production for the traditional rule of thumb, the development of new steels and new alloys, and the appearance of the continuous rolling mills—these are only a few of the great forward steps.

The results of these advances have been greater employment, better products, lower selling prices and wider markets. They have made it possible for the steel industry to multiply almost beyond calculation the range and extent of its services to all the people. And all this has been the contribution of research and engineering, combined with the capital and the man-

power and the management in the steel industry. As steel has rapidly ascended the scale of quality, prices have made no proportionate advances, but actually have declined, so that today at about three cents a pound steel is the cheapest of all important metals. That price, moreover is conducive to universal use.

Examples of what the improvements in steel have meant to other industries could be cited without number. Take the automobile, for instance. Actually the modern automobile, with its steel body and steel top, its light weight and high efficiency in every particular, could not have been built from the materials available in 1900. In 1911 only 18 different kinds of steel were used in manufacturing a motor car, while today the number of different varieties of steel used in the average automobile approximates 135.

Every one of these additional varieties represents the achievement of research and engineering, every one serves a useful purpose for the automobile maker and the public, every one helps to expand the market and make more jobs in the steel industry. What is true of the automobile industry is true of countless others.

New products and methods has widened steel market.

One does not have to be an engineer to recognize the steps by which American industry has moved forward in the development of new products, new methods and increasingly efficient processes. The whole economic geography of the United States has been greatly altered as a consequence of engineering in every field from agriculture to aeronautics. But whatever the field, success usually has hinged upon the performance of iron and steel.

If we examine the new outlets for steel in the light of industrial developments as they unfold before our eyes, it is easy enough to understand the recent expansion of the finishing facilities of the industry. The horizons of our markets are constantly widening.

I think no one can deny that the steel industry has every reason to be proud of its research and engineering achievements, of its proven ability to keep in step with the needs of the nation and of its great contributions to civilization. But there are other aspects of the industry about which we cannot boast, and the most conspicuous of these as its record of earnings. Despite all it has done for mankind in general, steel has been able to do very little for the people whose savings make its very existence possible.

The American Iron and Steel Institute has just made a study of the earnings of the industry over a period of nearly three decades, which must give us pause. It shows that in the ten year period from 1910 through 1919, the annual average return on investment in the industry was 8 per cent. From 1920 through 1930, it was 5.5 per cent; and from 1930 through the first half of 1938, the average annual return was only 1.5 per cent.

With an average investment of $4,737,000,000 during the last eight years, the average annual earnings for steel have been only $73,000,000. Since 1920, the surplus and reserves of the industry have been cut in two, declining from $1,879,000,000 to $980,000,000.

In the face of this record the steel industry frequently is accused by its critics of price fixing, extortion and monopoly. I fear that the real criticism of the industry is that it has failed to earn a reasonable return on the capital invested in the business. Of course, there are many reasons for that failure, some of them lying within the industry itself and some of them existing in causes over which the industry has no control. Certainly the poor returns during the thirties have reflected the depression years, but even in the one high production year in 1937, the industry was able to show a bare 6 per cent upon its capital investment.

Clearly, serious obstacles are in the path of profits for the industry even though volumes are large. I think everyone acquainted with the present relation of costs to prices in the industry will agree that the break-even point is higher than in many years, perhaps the highest it has ever been in all the history of modern steel making.

I have stressed the problem of profits in the industry because the importance of that problem is all too often overlooked or passed over lightly. Profits are the very lifeblood of our system of private enterprise. Without profits to tax, where would the government get the huge income it needs to pay at least a part of its going expenses—expenses which include interest on the vast public debt, relief, WPA work, and many other staggering items?

Unless the steel industry can demonstrate its ability to earn a fair return on capital investment, eventually it will face the time when it can no longer attract capital. Without capital to develop new products, to modernize its plants and to make jobs, steel would lose its power to serve the nation adequately and well.

Profitable industry necessary to economic welfare.

It would seem to be axiomatic that profitable industry makes for a prosperous country—that a profitable industry is distinctly in the interest of all the people. In fact, the material welfare of the people is inseparable from that of business. Every business is simply an aggregation of people, those who own it and those who are employed by it as managers or workers. You cannot really separate people and business and put them in opposing camps, because they are one and the same.

Yet in recent years public opinion has been led to sanction many moves which have tended to frighten capital and discourage enterprise. Basic changes have taken place in the economic and social life of the nation, many of them establishing new controls over business. Few people realize, I suspect, just how far we have gone in that direction. Let me enumerate just three examples as follows:

First, the control over wages and hours, in accordance with the provisions of the so-called "fair labor standards" act. While this act does not directly concern the steel industry, because steel wages are far above the legally fixed minimums, it does establish a principle of wage and hour control which might well be extended to the point of fixing the actual wage to be paid by all industry. From the control of wages it is but a step to the control of prices.

Second, the restriction of the right to accumulate profits in business as a reserve for lean times, by the so-called undistributed profits tax. While this tax has been relieved, the principle remains.

Third, the assumption of broad jurisdiction over

labor relations in industry by the National Labor Relations Board under the one-sided Wagner Act.

These are but a few of the controls over industry which deprive management of freedom of action and decision in matters vitally affecting the successful operarion of a business. On top of them is the wide use of the techniques of investigation and persecution of business through the medium of innumerable government bureaus, departments or committees. I can assure you when I make that statement I know whereof I speak. I think Republic has experienced every refinement of government inquisition and prosecution from a Department of Justice suit to block a merger to a Labor Board trial and a La Follette hearing.

In agriculture, of course, and in finance even more comprehensive controls are in effect, and for industry, according to reports, we have seen but the beginning. How far the attempt will be carried I do not know, but there are indications that under the cloak of still more reforms even more direct powers to regulate production and prices in industry may be sought. It is my understanding also that one of the matters marked for attention is that of limiting control over patents by the owners of patents.

I have said many times, and I repeat now, that in the complex age in which we are living some measures of governmental regulation of private industry may be necessary. To the extent that these regulations safeguard and promote the public interest they are good, and should be supported. But regulations and controls which discourage enterprise, which drive capital into the cyclone cellar, and keep people out of jobs, are not, to my mind, in the public interest.

We are standing at the crossroads in this country today. Down one road is free private enterprise, with exactly the degree of regulation as may be necessary for the public good. Down the other road is industry shackled, regimented, burdened—a road leading direct to some form of the collectivist state. The country cannot travel on both roads and in both directions at once. It must decide which way it wants to go.

Has no desire to return to the "good old days".

Do not misunderstand me. Despite all the names I have been called—I have lost count of all the different kinds of a Tory and reactionary I am supposed to be—I am not in the corner with those who would turn back the hands of the clock. I shed no tears over the so-called "good old days". I think the man who wants to run a business as it was run thirty or twenty or even ten years ago, is just crazy. Times have changed. Ideas have changed. Business methods have changed. Management must keep in step or it will get out of step and fall behind.

But there are some first principles affecting our individual lives and the economy of the nation, from which we have departed and to which we will have to return if we are going to preserve our institutions in this country.

We will have to return to the ideas that a nation and its people are only prosperous when business is prosperous; that America cannot thrive on class conflict and hate; that the interests of employer and employee are not at deadly odds; that the government cannot give charity except from taxes which come from the sweat and blood of the people; and that an individual; a business or a government cannot go on spending in excess of income without, in the end, facing bankruptcy.

Above all we will have to learn that a nation cannot create an abundance except by production and hard work.

I am for any real progress, any real improvement, any real reform which has been made which actually may advance the interests of the country and benefit all the people. For those objectives I have every sympathy and I am sure it is shared by every enlightened business man in America.

My opposition is reserved for phoney reforms, class legislation, clumsy controls, and the bungling methods which help no one.

I have spoken to you of some of the problems confronting industry in its effort to prosper because they are of deep concern to every one of us. As managers, as research engineers, it is not enough for us to concentrate upon the specialized job at hand in our own industry. We are compelled by events to widen the horizon of our active interest to include those basic economic issues which the nation is pondering today. As members of the great iron and steel industry we are part and parcel of those issues. Government is no longer something distant and apart from our daily lives. We could not, even if we would, avoid shouldering our share of the national burden.

Consider the item of taxes. That alone is sufficient to jolt us into a realization of how close the problems of government are to us and how much it is to our interest that sound solutions be found for these problems.

In 1937 the steel industry had profits that were 49 per cent below those for 1929, yet taxes last year were 65 per cent greater than in 1929. Think of it! The total amount of taxes paid by the industry in 1937 was equivalent to an outlay of $330 for each of the 513,000 wage earning employees. The industry's tax bill devoted to wages, would have kept 108,000 men at work for a full year.

The fact that the steel industry does not earn profits does not remove the tax incubus, because a large share of it consists of direct taxes imposed by states and municipalities, regardless of income.

The tax burden is but a symptom of the problems of unemployment, of relief and of security which are upon the country and which industry and those of us in industry must help meet and solve.

Stresses importance of such groups as the Association.

Industry has gone through many a crisis in this country, it has made enormous contributions to the welfare and wealth of the nation and our people. It is more competent, better prepared and more efficiently equipped to perform useful services and conquer new difficulties, in peace or in war, now than ever before. The very existence of an organization such as yours, representative of the engineering genius of a great industry, measures the tremendous advance made by steel since the time of Captain Jones, and is a promise for the future of the industry and for the country. You have helped the country attain its present high standing in the world. You now must help it dissolve its present troubles and to move on to further achievements.

"I FIGURE WE SAVED SINCE WE INSTALLED

. . HERE ARE THE FACTS

says Mr. E. K. Sprague, Electrical Engineer, The Patent Button Co., Waterbury, Conn. "We were averaging about three complete shutdowns a week due to main fuses blowing.

"On January 28, 1938, we installed BUSS Super-Lag Fuses. To date (April 16th) we have not had a single shutdown.

"I figure this is due to the design of the BUSS Fuse and to the eliminating of poor contact at the clips—and that the combination saved the company at least $100.00 a week.'

BUSS *Super Lag*

ABOUT $100.00 A WEEK BUSS FUSES"!

You too, can
ABOLISH WASTEFUL SHUTDOWNS CAUSED BY NEEDLESS BLOWS

It may come as a surprise to some executives that many shutdowns supposed to be caused by trouble in the circuit, really originate in the protective devices themselves.

To prevent this costly waste – caused by protective devices opening needlessly – BUSS developed the Super-Lag fuse.

If you are even remotely interested in a smooth running plant – or saving money due to more efficient plant operation – you will find it well worth your while to pass the word along that in the future all requisitions and purchase orders call for BUSS Super-Lag fuses.

If you would like to be able to show others why BUSS Fuses are suited to the needs of your plant we will be glad to send you a copy of the RB book. It gives in easy reading style a comparison of BUSS construction with others – and makes clear how BUSS Super-Lag Fuses can help abolish unnecessary shutdowns in your plant.

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WHY BUSS FUSES
DON'T BLOW NEEDLESSLY
10 FEATURES
in the design of the FUSE-CASE help make it possible..
The SUPER-LAG
development in the FUSE-LINK completes the job.

FUSES

A. I. & S. E.

EDUCATIONAL PROJECTS

H. G. R. BENNETT, *Chairman*
EDUCATIONAL PROJECT COMMITTEE

▲ HAVING for some time considered the advisability of promoting some form of educational project, the Association of Iron and Steel Engineers, late in 1937, launched an experimental plan whereby each of its sections was to carry out a plan of its own choosing. Under the general direction of H. G. R. Bennett, assistant general superintendent, Carnegie-Illinois Steel Corporation, Duquesne, Pennsylvania, and at that time president of the Association, the idea was developed so as to work out projects that would be of benefit to the interests of the iron and steel industry through the advancement of the direct education of individuals engaged in the industry, through some form of improvement as accomplished by research development work, or through furthering some additional facilities in colleges concerning a subject directly related to the industry.

Accordingly, each section of the Association was allotted the sum of $1000 and authorized to proceed with the development of a plan conforming with the general provisions as outlined above. An educational committee was formed in each section to investigate various ideas and to formulate the sectional projects, subject to the approval of the national educational committee.

At the present, a definite plan has been adopted by each section and each has been carried to various stages of completion.

BIRMINGHAM SECTION

The educational committee of the Birmingham Section, after conferring with the educational institutions in that district, decided upon the establishment of two metallurgical, mechanical or electrical post-graduate scholarships of $500.00 each, one at the University of Alabama and the other at Alabama Polytechnic Institute. The recipients of these scholarships were selected by the committee of the Birmingham Section from several applicants selected or recommended by the engineering faculty of the respective schools. Final selection was based on scholarship and general qualifications, with the added requirement that the work to be covered be of such a nature as to promote or advance engineering knowledge pertaining to the iron and steel industry.

This project began in September of this year, one scholarship being on mechanical lines and one on metallurgical lines, and will run through the 1938-1939 school year.

CHICAGO SECTION

In the Chicago district, the committee contacted the heads of various steel companies as well as the near-by universities, asking for suggestions and recommendations. The ideas emanating from the various sources varied considerably, depending on the particular problem or need of the company or school making the suggestion. After considerable deliberation, it was decided to establish an evening class, of 100 men, covering the fundamental principles of iron and steel production, for those who desire to supplement their knowledge of a special technique with a broad general knowledge. Topics which will be considered include raw materials, refractories, coke ovens, blast furnace, open hearth, Bessemer and electric furnace processes, rolling, forging, steel defects, physical properties, constitution and structure of iron and steel, heat treatment, metallography, etc.

This course is divided into two semesters, and will run one evening a week for about thirty-six weeks, starting September 27th. It will not be highly technical. The cost will be partially borne by the students, who will be chosen largely from the district employees of Carnegie-Illinois Steel Corporation, Inland Steel Company, Youngstown Sheet and Tube Company, Republic Steel Corporation, Wisconsin Steel Works, Acme Steel Company, and Interlake Iron Corporation. Selection of the students is made largely through the company managements.

PITTSBURGH SECTION

After due consideration, the plan adopted by the educational committee of the Pittsburgh Section consisted of a gift of $1000 to the endowment of Carnegie Institute of Technology as a loan fund for juniors, seniors or graduate students whose courses or stated

intentions indicate an interest in the iron and steel industry. The fund is administered by C. I. T., and is subject to their regulations regarding loan funds. Records and experience of the fund are available to the Association of Iron and Steel Engineers so that the effectiveness of the fund may be determined.

This plan became effective in March of this year.

CLEVELAND SECTION

Sentiment in the Cleveland Section strongly favored the distribution of the benefits of any plan over as large a group as possible, rather than confining it to one or two individuals. A survey of the local situation finally led the Cleveland committee to sponsor a course in elementary electrical engineering, at no cost to the student. The course was presented by Case School of Applied Science, and included lectures, laboratory work and home problems with their discussion. Starting February 8th of this year, the class met twice a week for fifteen weeks.

Sixty-three men were selected to take the course, including turn foreman, motor inspectors, electrical and mechanical apprentices, and electrical repair shop men from National Tube Company, Republic Steel Corporation, Otis Steel Company, American Steel and Wire Company, Timken Roller Bearing Company, Superior Sheet Steel Company, etc. Selection was made by the committee from lists obtained from departmental superintendent of the companies.

Of the original enrollment of sixty-three men fifty-nine carried it to completion. Eighteen individuals had a perfect attendance record, while the average attendance for the entire course was 87½ per cent, in spite of the fact that one-third of the group lived from 35 to 60 miles from Cleveland. Investigation of absence showed the majority to be due to night work or sickness.

This course was well received, and many requests were made for both a repetition of the course for another group and an advanced follow-up for the same group.

PHILADELPHIA SECTION

The plan decided upon by the committee of the Philadelphia Section is that of establishing a fellowship for the purpose of study on a subject of interest to the iron and steel industry. Eligibility for candidacy required graduation from a recognized college and at least one year's experience in a steel plant. Selection of the candidate was made by the committee on a competitive basis.

This fellowship became effective at Lehigh University September 1st, and will run for the ensuing school year. Research will be conducted on the matter of causes and properties of woody fractures in steel.

▲

The results of these several educational projects will be carefully studied and should furnish helpful guidance to the selection of any future educational work as might possibly be programmed by the Association. The board of directors, at its September meeting, again allotted each section $1000 to carry on similar activities for the coming year.

Report of

MEMBERSHIP COMMITTEE

▲ AN active campaign for new members was instituted in January of this year, principally through letters to the members enlisting the total membership in this committee. A very generous response was obtained. There seemed to be a real interest universally on the part of all members to enlarge our organization. The amount of individual effort put forth was reflected in the flood of applications received. Our original request was rather a modest one in that one new member was set as a minimum for each member. The replies seemed to indicate there was a contest on to see who would get the most new members. The man who won first place in this contest out-distanced every one so far that he had to organize a new section to take care of them. As was formally announced this individual effort resulted in our new Detroit section. Mr. Julius Clauss, Chief Engineer of the Great Lakes Steel Corporation deserves the credit for his untiring efforts in putting over this new venture. Mr. Clauss is to be congratulated for this unusual performance.

G. R. CARROLL, *Chairman*
MEMBERSHIP COMMITTEE

Although our campaign opened in January and ended in April we continue to receive more applications daily. One very significant factor reflected in our roster of new members is the large number of executives included who are showing enough interest in our organization to become members.

The number of new members enrolled to date since January totals 334 which we believe is a noteworthy result. They are divided geographically as follows:

Pittsburgh	125	Chicago	36
Detroit	86	Cleveland	36
Philadelphia	39	Birmingham	12

The committee wishes to express its appreciation for this hearty response from the membership.

✓Check the Features OF THIS NEW-TYPE BEARING

Bantam Standard Quill Bearings have these advantages:

1. **ONE-PIECE channel-shaped outer race with rollers definitely retained.**
2. **Simplified design—No fragile parts—Easy to assemble.**
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4. **Correctly proportioned rollers with husky curvilinear trunnions.**
5. **Rigid surfaces, accurately hardened and ground, confining rollers endwise.**
6. **Low cost made possible through large production, simplified design.**

WIDE RANGE OF SIZES CARRIED IN STOCK

Bantam Standard Quill Bearings are carried in stock in a range of sizes for shafts from ½" to 5".

Users of large capacity radial bearings (anti-friction or plain), will find these outstanding new bearings of extreme value. *Send for Bulletin 103 E* which contains full engineering data.

For Needle Bearings to be used in lighter service request Circular 19A from our affiliate, The Torrington Company, Torrington, Conn.

BANTAM BEARINGS CORPORATION
SOUTH BEND, INDIANA
Subsidiary of THE TORRINGTON CO., Torrington, Conn.

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TAPERED ROLLER · · · STRAIGHT ROLLER · · · BALL BEARINGS

TO PREVENT CONTACT STEEL PICKS PENOLA

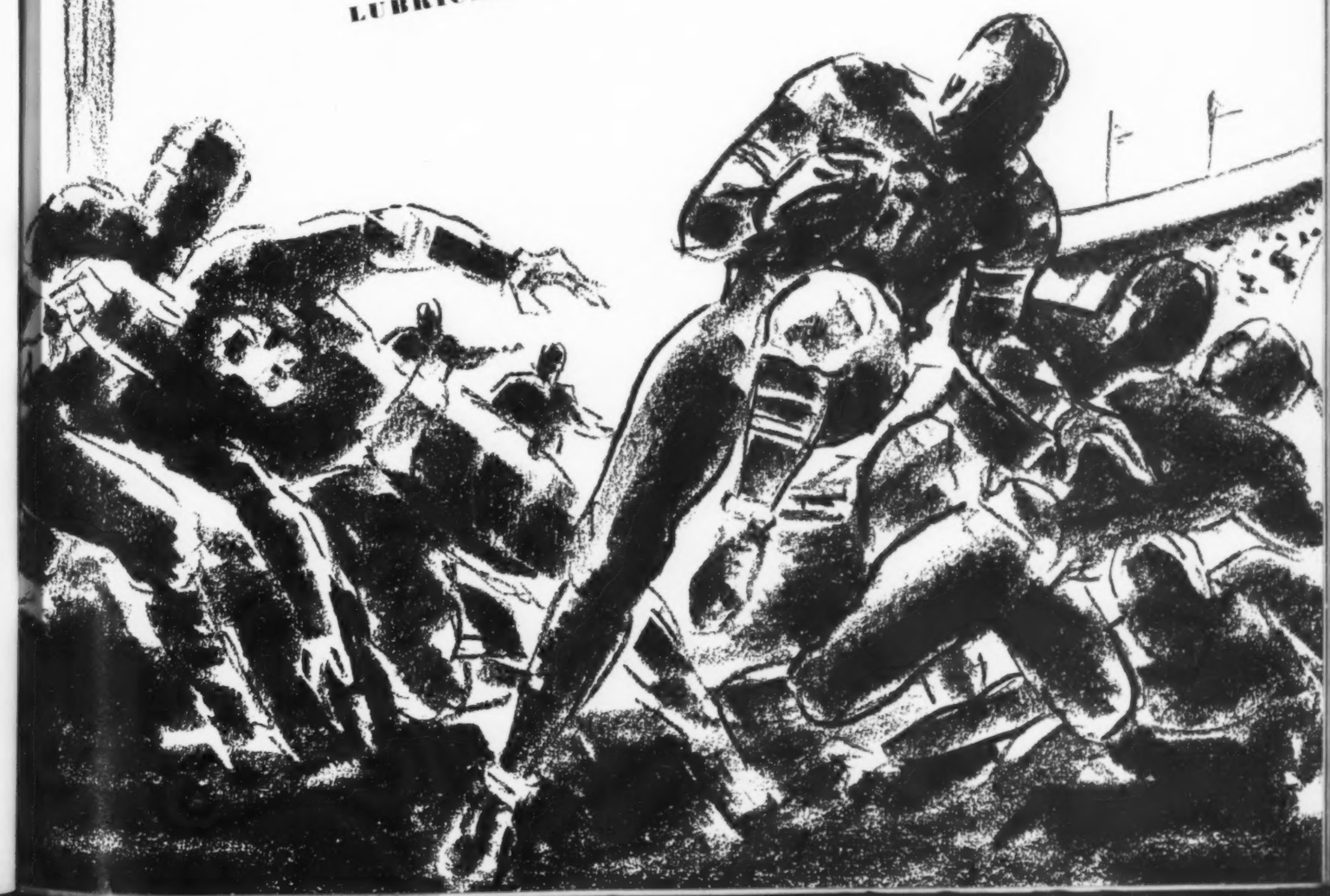
WHERE reduction gears may cost many thousands of dollars, prevention of metal-to-metal contact is of vital importance. And when normal pressures exceed 3,000 pounds per lineal inch of tooth face, prevention of that contact is one of lubrication's most difficult jobs. Penola succeeded by producing Extreme Pressure Lubricants that withstand 3 to 5 times the pressures that cause ordinary lubricants to fail. Through handling the toughest jobs, Penola has convinced the steel industry that Penola means quality lubricants for all applications. That is why Penola makes and sells more steel mill lubricants than any other maker in the world.

• • •

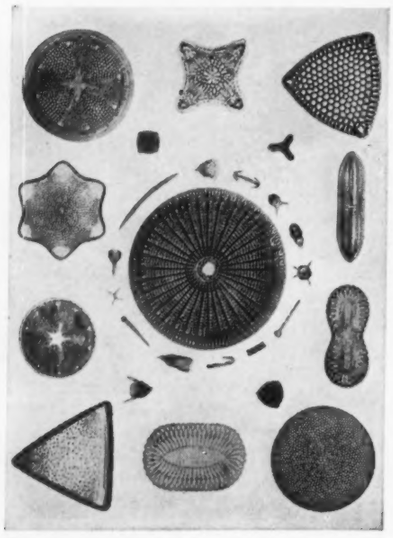
PENOLA LUBRICANTS

PENOLA INC., PITTSBURGH, PA.
(Formerly Pennsylvania Lubricating Company)
NEW YORK • CHICAGO • DETROIT • ST. LOUIS

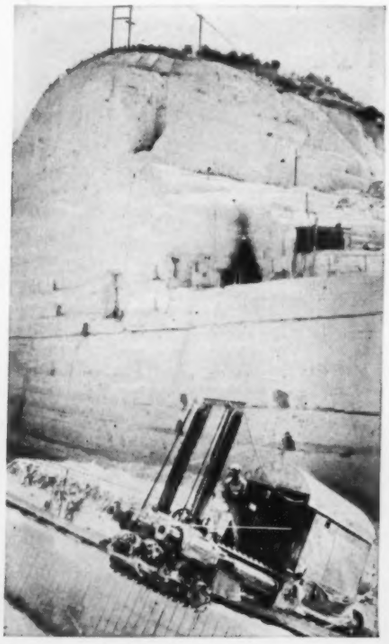
LUBRICANTS FOR THE STEEL INDUSTRY SINCE 1885



HOW TINY SEA PLANTS SAVE INDUSTRY MILLIONS OF DOLLARS EVERY YEAR



1 Under the microscope, diatoms present an amazing variety of intricately beautiful designs. Each is the skeleton of a complete single-celled organism that lived and died about 50,000 centuries ago. Settling to the ocean bed, these tiny plants built up a vast deposit of diatomaceous silica . . . one of the most efficient high-temperature insulating materials known today.



2 The Lompoc deposit of diatomaceous silica in California, owned by Johns-Manville, covers an area of five square miles and is 1400 feet deep. High-temperature insulations for many of the world's largest utilities and industrial plants have come from this chalklike cliff. More than 100 million tons of Celite are included in the deposit, the largest and purest ever discovered.

NEAR Lompoc, California, lies a vast deposit of Celite . . . one of the most useful substances known to man. Geologists call it "diatomaceous silica." It is porous, has a chalklike appearance and is unusually light in weight. Look at some of the powder under a powerful microscope and you will see what it really is . . . a mass of minute skeletons of tiny sea plants that lived and died millions of years ago when California was part of the ocean floor.

Up to about 1900, these tiny organisms served no useful purpose. Their peculiar properties were unknown . . . the need for them had not been developed. But with the increasing demand for more efficient industrial insulating materials, Celite soon was put to work. Tests showed that, because of its enormous number of dead-air cells and the high heat resistance of its silica composition, Celite was a far better insulating material for high temperatures than any substance previously used.

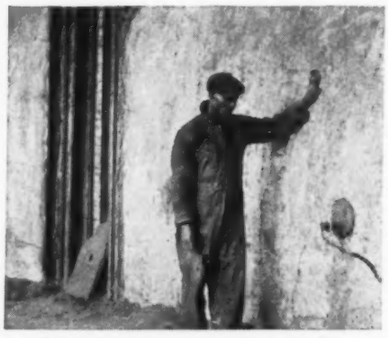
Today, Johns-Manville manufactures Celite into the well-known Sil-O-Cel materials—Sil-O-Cel Natural, C-22 and Super Brick, Sil-O-Cel Powder, and Sil-O-Cel C-3 Semi-Refractory Insulating Concrete. And, when bonded with asbestos fiber, Celite is also made into the widely used Superex Insulation for high-temperature industrial furnaces and superheated steam lines.

These and other J-M Insulations are now used wherever high temperatures are used in industrial processes. By preventing heat waste, they save industry many millions of dollars a year. The complete story of the remarkable strides made in controlling heat during the last 25 years is told in J-M's interesting handbook, "Heat." For your copy, and complete information on the full line of J-M Insulations for all industrial purposes, write Johns-Manville, 22 East 40th Street, New York, N. Y.

JOHNS-MANVILLE

INSULATIONS FOR EVERY TEMPERATURE . . . FOR EVERY SERVICE CONDITION

3 One cubic inch of Celite from the Lompoc deposit contains as high as 75 million separate diatoms. This explains its exceptional insulating efficiency, as the resistance of any material to the flow of heat depends directly on the number of separate surfaces per inch of thickness. Johns-Manville makes this remarkably efficient insulating material into many different forms to meet every industrial requirement. This strip-annealing furnace is being insulated with J-M Sil-O-Cel C-22 Brick.



4 Made into semi-refractory insulating concrete, Celite is used for furnace bases and door linings, baffles, dampers, etc. Sil-O-Cel C-3 Concrete, shown here, is over three times as effective as fire-clay brick in reducing heat transfer . . . needs no other refractory protection against direct temperatures as high as 1800° F.

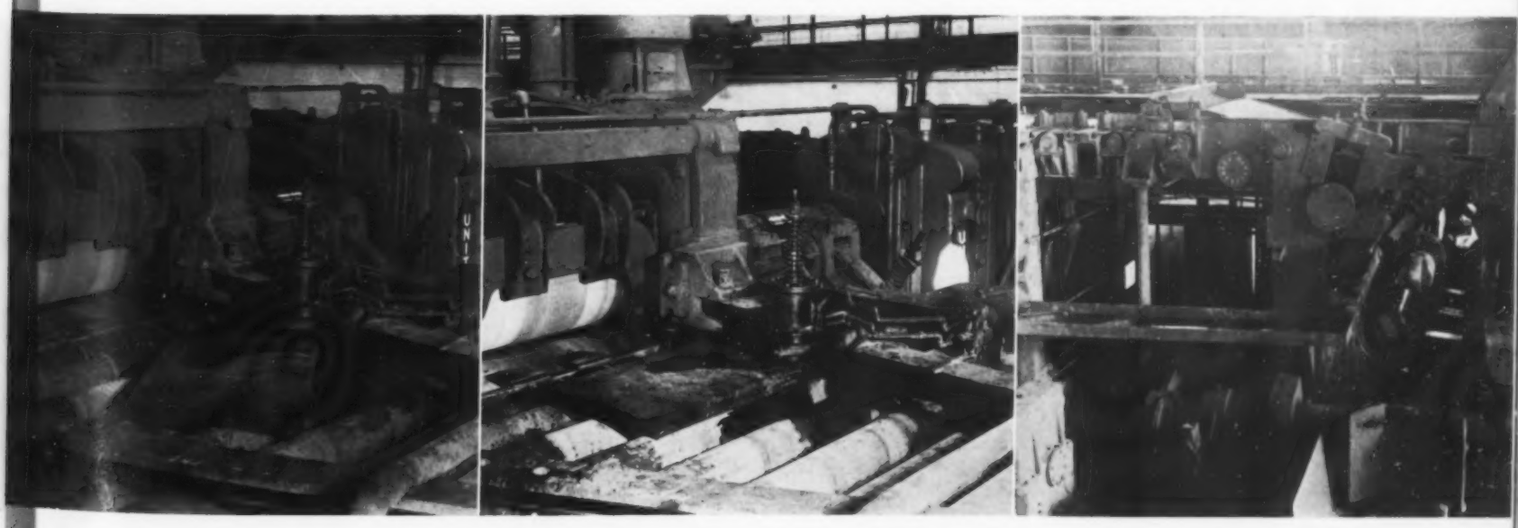
5 Bonded with asbestos fiber, Celite is formed into J-M Superex Blocks, being used here to insulate a soaking pit in a large Eastern steel mill. Superex, also manufactured in pipe-covering form, is recognized as the outstanding insulation for superheated steam lines, boilers and high-temperature industrial furnaces of every type. There is a J-M Insulation for every industrial requirement.

DEVICES ORIGINATED BY OTIS STEEL MEN AID STRIP MILL PRODUCTION

▲ Although most of the various improvements entering into steel mill equipment are usually associated with the manufacturers of the equipment, many such improvements actually originate with the mill operators. Some of these are picked up and applied by equipment manufacturers, while others, perhaps no less important or valuable, are limited by conditions to local application. The recently modernized continuous strip mill at Otis Steel Company, Cleveland, Ohio, has several such devices, originated by J. S. Spellacy, superintendent of the 77″ hot strip mill and Tom Burrell, master mechanic of the same department.

The original slab turner used on the Otis mill consisted merely of a slab fixed across the roller table, in which a number of holes were drilled for the insertion of a pin. As the slab proceeded down the table, the pin struck one corner of the slab, arresting its motion while the table rolls carried the slab on around through 90 degrees. This contrivance, however, was not positive, and resulted in many delays, as the slab would lodge in the side guards and would not always turn through the required 90 degrees, due to the pin slipping. To obviate this trouble, a positive catch was installed, consisting of two cylinders with air-actuated plungers and springs. A trigger lever is installed on the air line, and as the slab approaches the proper point, the lever is thrown and air pressure forces the plungers above and below the slab into contact with the corner of the slab, holding it fixed until the slab is carried by the table rollers through 90 degrees, when it strikes a release spring valve set in the side guard of the table, which releases the plungers from the slab. (Figures 1 and 2) This device, built in the plant at slight cost, serves satisfactorily as a slab turner.

In the hot coiler there are six rolls in a housing, with apron plates between the rolls which guide the strip from roll to roll and into coil form. In rolling some of the light guages much trouble was encountered due to the sharp ends of the strips catching between the apron plates and the rolls in the coiler, resulting in cobbles. This



Figures 1 and 2—(Left and center) Operation of the new slab turner on the Otis strip mill. Figure 3—(Right) The dial indicator makes coiler roll position visible to the operator.

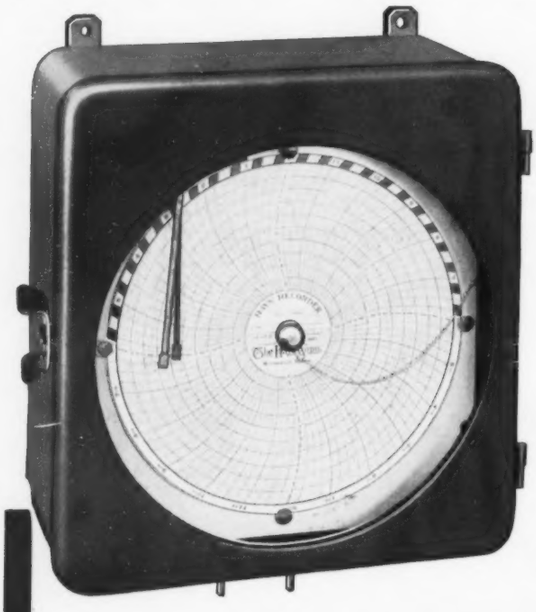
trouble was eliminated by grooving the rolls in the coiler and cutting the apron plates with fingers which dovetail into the grooves in the rolls.

The position of the rolls and apron plates is electrically controlled from an operating pulpit from which the rolls are not visible. Occasional improper functioning of this control would result in the rolls being out of proper position, causing a cobble. To make the roll position visible to the coiler operator, a dial indicator was mechanically connected to the cam which controls the closing of the coiler rolls (Figure 3). If the cam-controlled rolls of the coiler are out of position, as indicated by the dial indicator, it is noticed by the coiler operator, and the necessary adjustments can be made, thus preventing cobbles and scrap.

Another device has been installed on the roughing scalebreaker, consisting of a small motor and reduction gear to electrically change the setting of the side guards on the entry side of this stand. Previously, this setting, which must be changed for different slab widths, was made by means of a hand reel, and it was necessary for two men to cross the mill table to make the adjustment. The substitution of the electrical drive has eliminated a very hazardous operation.

With the knowledge that there are literally thousands of similar ideas in use in the steel plants today, and in the belief that the interchange of such ideas will be beneficial to the industry, the "Iron and Steel Engineer" desires to offer due recognition to the ingenuity of the steel plant men. If you have a new method of doing a job, a novel idea, an original "kink" or "gadget", that has improved quality, increased production, eliminated safety hazards, or lowered costs, pass it along. Such material is solicited.

REGISTERS DRAFT,
PRESSURE AND DIFFERENTIAL
in
SOAKING PITS
•
ANNEALING FURNACES
•
OPEN HEARTHS
•
SLAB MILLS



HAYS "OT" DRAFT RECORDERS

Results in a better product because it gives a correct indication of furnace atmospheres. Built husky enough to stand the severest steel mill conditions yet sensitive enough to register accurately in increments of .0025 in. water. Employs the famous Hays Slack Leather Diaphragm —self sealing—not damaged under sudden excess pressures. Two draft valves, two pressure valves, two differential valves, or a combination of any two of these three valves may be recorded. Or a temperature recorder may be substituted for one of these valves. Send for descriptive literature

To OPERATING MEN and ENGINEERS: Have you entered the S. A. M. A. Instrumentation Contest? Write us for full particulars.

The HAYS CORPORATION
SINCE 1907
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A

DISCHARGE INDICATOR PREVENTS "TOW-INS"

▲ Electric Storage Battery Company, Philadelphia, Pennsylvania, announces a new model of the Exide discharge indicator, a device for use on electric industrial trucks and tractors.

The new model discharge indicator is assembled in an unusually sturdy case, practically unbreakable under normal conditions, while the mechanism inside is further protected by spring suspension which enables it to absorb further shocks without damage.

The function of the discharge indicator, which is mounted in front of the operator, is to enable the owner of industrial trucks to maintain his trucks at a higher and more uniform speed throughout the day's operation. It accomplishes this by warning the operator that the battery is approaching a discharged condition and should be changed or recharged, thus eliminating time-consuming "tow-ins".

The warning is in the form of a red light, which is seen by the operator. At first there are momentary flashes as the time for recharging approaches —the light going out when the truck attains full speed. With each run, as the battery discharges further the light remains on for a longer time. But when the point is reached that the light remains on all the time the

truck is running, the operator knows the truck should go in for a battery change or recharge.

The accuracy of the new model discharge indicator has also been developed to a high point.

ALIQUIPPA PLANT OF JONES & LAUGHLIN HAS FINE SAFETY RECORD

▲ Although working in a roaring plant where thousands of tons of steel in molten and solid form are handled daily, the employes in the Aliquippa Works of the Jones & Laughlin Steel Corporation have been safer for the past year at their work than on the highway or even in their homes.

The 12,000 employes in this plant have worked more than fourteen million man hours since September 1, 1937 without a fatal accident, yet during the same period seven employes have been killed outside the plant. Automobile accidents accounted for five of the deaths, one man was murdered, and the other fell to his death from a second floor window of his home.

This is not the first time that Jones and Laughlin plants have operated for many months without fatal accidents, one accident-free period having run for nearly two years.

IMPROVED TYPE OF LIGHTING UNIT

▲ Holophane Company, 342 Madison Avenue, New York, New York, announces a new development. The In-Bilt lighting installations are now possible with minimum installation difficulties and expense. This new method of recessing Holophane reflector refractors brings to this type of lighting the unusually fine light controlling qualities of reflector-refractors plus the modern appearance feature. Easy relamping is accomplished through the removable cup in the refractor member of the unit. Interested persons may obtain additional information by writing the Holophane Company.

▲ Bull Dog Electric Products Company just published a revised edition of their Universal Trol-E-Duct Catalog. This catalogue describes their unique wiring system for industrial plants and commercial buildings. It is profusely illustrated showing construction details and installation views.

Interested persons desiring this catalogue should write for Catalogue No. 386, in care of the Bull Dog Electric Products Company, 7610 Jos. Campau Avenue, Detroit, Mich.

▲ Leeds and Northrup Company has issued a completely revised roof temperature bulletin. This booklet entitled, "Temperature—Limit Control for Furnace Roofs", contains information on new methods of automatic temperature control, recording and indicating.

Copies of this bulletin may be obtained by writing for No. N-33B-600B. Address: Leeds and Northrup Company, 4901 Stenton Avenue, Philadelphia, Pennsylvania.

FARREL GEARFLEX COUPLINGS

Made in 18
Standard Sizes
from 2″ to 20″

Here is shown the extreme range of sizes in the standard Gearflex double engagement type coupling--the huge 20″ with the little 2″ on top.

Farrel Gearflex Couplings of the double engagement type are made in a complete range of sizes for shafts from 2″ to 20″ in diameter. In addition there are several other types with a wide range of sizes in each type, providing a selection for a variety of applications and special service conditions.

In every size and type Farrel Gearflex Couplings are all-steel flexible couplings, dust-proof, moisture-proof and positively lubricated. Accurately generated external and internal spur gears insure precision and uniform distribution of the load over a large number of contact surfaces. The oil film between the teeth cushions the load and makes for silent operation and long life.

They provide complete flexibility, compensating for parallel or angular misalignment, or a combination of both, protecting connected machines from possible damage resulting from misalignment. They also permit free lateral or end float of connected shafts.

For complete details send for copy of catalog giving ratings, dimensions, weights and other engineering data.

FARREL-BIRMINGHAM COMPANY, INC.
366 VULCAN STREET BUFFALO, N. Y.

FARREL SYKES GEARS — *The Gear with a Backbone*

ITEMS OF INTEREST

John S. Kenney formerly electrical superintendent of maintenance and construction of the Wheeling Steel Corporation, Yorkville, Ohio, has been appointed superintendent of that company's cold strip department at Yorkville. Born in Steubenville, Ohio, Mr. Kenney, after completion of his education, became associated with La Belle Iron Works at that place in 1910. In 1913, he associated himself with Wheeling Sheet and Tin Plate Company, Yorkville, Ohio. That firm was later consolidated with Wheeling Steel and Iron Company, Wheeling, West Virginia, and in 1920, the latter firm became a subsidiary of Wheeling Steel Corporation.

During 1928 there was installed at the Yorkville Works the first cold strip tin mill in America at which time Mr. Kenney became electrical superintendent of maintenance and construction for the entire plant. In 1934, a second and larger cold strip tin mill went into operation, and in 1937 a third such mill was installed. During the early part of this year, Mr. Kenney was elevated to the position of superintendent of the entire cold strip department.

▲

E. M. Fieger has been appointed construction engineer for the Carnegie-Illinois Steel Corporation, Gary Works, Gary, Indiana. Mr. Fieger was the construction engineer of the new Irvin Works at Clairton, Pennsylvania. He began his service with United States Steel Corporation subsidiaries in 1903 as a mechanical draftsman with the former American Sheet and Tin Plate Company in Pittsburgh. In 1905, he became assistant to the chief engineer and four years later was sent to Gary to oversee the initial construction of the Gary sheet mill of the same company. Becoming civil engineer and construction engineer in 1910, his duties took him to all plants of the company. In this capacity he supervised the construction of the first and second units of the Gary tin mill and was active in the installation of the 42" hot strip mill there. This was the first mill of its kind in the plants of the United States Steel Corporation subsidiaries. When the American Sheet and Tin Plate Company became part of the Carnegie-Illinois Steel Corporation in 1936, Mr. Fieger remained in the civil engineering department in Pittsburgh until 1937, when he was appointed construction engineer of the new Irvin Works, the position he has held until the present time.

▲

J. K. Devitt was appointed chief civil engineer of the Gary Works of the Carnegie-Illinois Steel Corporation. Mr. Devitt was the former assistant chief civil engineer at Gary. He began his association with the steel industry as an engineer with the Shenango Furnace Company in 1906. He remained with this company until April 1, 1910, when he became a civil engineer at the Gary Works. In 1916, he was appointed assistant chief civil engineer and served in that capacity until his recent appointment.

▲

A. E. Gibson and **Mrs. A. E. Gibson** were jointly presented with the Grand Award of the James F. Lincoln Arc Welding Foundation. The award amounted to $13,641.33. Mr. Gibson and Mrs. Gibson are president and stockholder, respectively, in the Wellman Engineering Company, Cleveland, Ohio. Mrs. Gibson holds a bachelor of science degree and master's degree in chemistry. Judged by a jury of thirty-one engineering authorities, the studies showed a saving of $1,600,000,000 available to industry by wider application of the arc welding process.

▲

Bert L. Wood has been named engineer in charge of a new program for the promotion of the broader use of light steel construction in buildings. Mr. Wood, formerly of the Carnegie-Illinois Steel Corporation, will direct his activities toward getting an

E. M. FIEGER

J. K. DEVITT

JOHN S. KENNEY

ROCKBESTOS *does away with "Maintenance"*

Whether you are most anxious to save time or money doesn't matter if you use Rockbestos in your wire-wrecking circuits, because you save both. No need for continually sitting on the lid of heat-dried trouble-making runs waiting for them to pop. No need for repeated rewiring and expensive installation. As the chief electrician of a shipbuilding plant puts it: "No periodic replacement just when attention is needed elsewhere" . . . or as another says: "I use Rockbestos in heat, oil and dampness and forget it."

You, too, can forget your circuits if they are wired with Rockbestos asbestos insulated wire because it's heatproof, fireproof, vibrationproof, and resistant to oil, grease and corrosive fumes. Send for samples and a catalog. Rockbestos Products Corporation, 900 Nicoll Street, New Haven, Conn.

Also refer to Electrical World Buyer's Reference Number of 1938.

ADEQUATE WIRING SERVES AND SAVES

OTHER ROCKBESTOS FEATURES

IT IS VIBRATION-PROOF

Rockbestos insulation won't dry out, crack, open up, or fall off.

IT WILL NOT BLOOM

Rockbestos won't rot, bloom or swell under action of oil, grease or fumes.

IT HAS GREATER CARRYING CAPACITY

Rockbestos' greater carrying capacity saves conduit replacement, labor and money.

IT IS HEATPROOF

Rockbestos insulation, made of asbestos, does not deteriorate under heat. It's flame-proof, too.

IT IS PERMANENT

Rockbestos is always "as good as new" because asbestos is naturally time resistant.

equality of recognition for light steel products with other kinds of building materials.

Mr. Wood, a graduate engineer of Cornell University, had been associated with Kalman Steel Company and Bethlehem Steel Company before joining the Carnegie-Illinois Steel Corporation.

▲

V. A. Hain was made sales manager of Flinn and Dreffein Company, Chicago, Illinois. Mr. Hain was for twelve years Chicago district manager of George J. Hagan Company, and more recently in a similar capacity with the Electric Furnace Company.

▲

Wallace K. Brown has been appointed vice-president and general sales manager of the Crocker-Wheeler Electric Manufacturing Company, Ampere, New Jersey. Mr. Brown was educated at Clarkson Tech and the University of Illinois, starting with the Crocker-Wheeler Company as an engineering apprentice, and was later located in the Chicago, San Francisco, and New York sales offices. B. D. Christian, vice-president and formerly general sales manager, will continue in an administrative capacity.

▲

R. J. Wean, president of the Wean Engineering Company, Inc., Warren, Ohio, has been elected a director of the Wellman Engineering Company, Cleveland, Ohio.

▲

W. A. Maxwell, Jr. has been elected president of the Colorado Fuel & Iron Corp., Denver, succeeding Arthur Roeder, who had been president since 1929. A graduate of Pennsylvania State College, Mr. Maxwell had previously been general superintendent of Inland Steel Co. of Chicago before joining the Colorado corporation in 1927.

▲

James M. Woltz, nationally known for his industrial plant safety work, and one of the organizers of the National Safety council, has resigned as supervisor of plant police for the Youngstown Sheet & Tube Co., Youngstown, O. He entered the employ of the company in 1913, after being a postal inspector for 19 years. For many years he had been safety director for the Sheet & Tube Company. His resignation took effect October 1, and he is leaving to spend the winter with Mrs. Woltz in Florida.

Vernon J. Crouse, for many years a member of Sheet & Tube safety forces, has been named to succeed Mr. Woltz.

▲

E. G. Puttman, assistant chief engineer of the Loewy Engineering Company, London, England, was one of the many recent additions to the membership of the Association of Iron and Steel Engineers.

▲

Fred V. Gardner was elected as acting treasurer, Chain Belt Company, Milwaukee, Wisconsin. Mr. Gardner, who will fill the vacancy created by the recent death of C. L. Pfeifer, has been connected with the company since early in the year.

ADVERTISING PAGES REMOVED

Obituaries

John J. McQuillen, formerly Pittsburgh district sales manager of the Morgan Engineering Company, Alliance, Ohio, died recently in Corning, New York.

JOHN J. McQUILLEN

Mr. McQuillen was identified with the Morgan Engineering Company for 45 years, most of that time in the position he held at the time of his retirement.

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF

IRON AND STEEL ENGINEER

(Required by Act of Congress of August 24, 1912)

Name of Publication: Iron and Steel Engineer, published monthly at Pittsburgh, Pa. (Report of October 1, 1938.)

Editor—Brent Wiley, Empire Bldg., Pittsburgh, Pa.

Business Manager—James D. Kelly, Empire Bldg., Pittsburgh, Pa.

Names and addresses of stockholders holding 1 per cent or more of total amount of stock: None.

BOARD OF DIRECTORS

1938

President, L. F. Coffin, Superintendent Mechanical Department, Bethlehem Steel Company, Sparrows Point, Md.

First Vice President, C. C. Wales, Assistant General Manager, Algoma Steel Corporation, Saulte Ste. Marie, Ontario, Canada.

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Honorary Director, E. Friedlander, Pittsburgh, Penna.

Honorary Director, A. C. Cummins, Assistant Manager of Operations, Pittsburgh District, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania.

Past President, H. G. R. Bennett, Assistant General Superintendent, Carnegie-Illinois Steel Corporation, Duquesne, Pa.

Past President, G. R. Carroll, Assistant Superintendent of Maintenance, Jones and Laughlin Steel Corporation, Aliquippa, Pa.

Treasurer, F. E. Flynn, General Manager, Warren District, Republic Steel Corporation, Warren, Ohio.

Secretary, J. L. Miller, Assistant Chief Combustion Engineer, Republic Steel Corporation, Cleveland, Ohio.

Director, C. C. Pecu, Lubrication Engineer, Bethlehem Steel Company, Lackawanna, N. Y.

Director, C. L. McGranahan, Assistant General Superintendent, Jones & Laughlin Steel Corporation, Pittsburgh, Pa.

Director, J. A. Clauss, Chief Engineer, Great Lakes Steel Corporation, Ecorse, Michigan.

Director, F. E. Leahy, Fuel Engineer, Youngstown Sheet and Tube Company, Youngstown, Ohio.

Director, E. C. Marshall, Chief Electrical Engineer, Youngstown Sheet and Tube Company, Youngstown, Ohio.

Director, J. F. Headlee, Assistant to Chief Engineer, Carnegie-Illinois Steel Corporation, Jary, Indiana.

Director, J. E. Harrell, Chief Electrician, Tennessee Coal, Iron and Railroad Company, Fairfield, Alabama.

Director, E. F. Blank, Director, Personnel Relations, Jones and Laughlin Steel Corporation, Pittsburgh, Pa.

Director, A. W. Steed, Maintenance Superintendent, American Rolling Mill Company, Middletown, Ohio.

Known bondholders, mortgages and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages or other securities: None.

BRENT WILEY, Editor.

Sworn to and subscribed before me this first day of October, 1938.

G. WILLIAM JONES, JR., Notary Public.

(My commission expires February 9, 1939.)